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EXPERIMENTS IN BREEDING SWEET CORN.

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BULLETIN No. 183

EXPERIMENTS IN BREEDING SWEET CORN.*

By

RAYMOND PEARL AND FRANK M. SURFACE.

INTRODUCTION.

The raising of sweet corn for canning purposes constitutes one of the most important of the specialized agricultural interests of Maine. Throughout the central and southern portion of the State sweet corn is the great "ready money" crop. In this section almost every town has its "corn shop" or "factory" and some places can boast of two or three.

The present magnitude and financial importance of the sweet corn growing and packing industry in the State is probably primarily due to the superior quality of Maine grown corn. "Maine sweet corn" justly holds a high reputation for flavor. To such an extent is this the case that before the advent of the Pure Food Law the labelling of corn grown in other states as "Maine grown" was very common indeed.

Some idea of the amount of sweet corn annually grown and packed within the State may be gained from the following figures, furnished by the National Canners' Association for the 1908 sweet corn pack of the country. While not official, these statistics probably fairly represent the general relations.

State	*Cases*
Iowa	1,085,000
Maryland	1,010,000
Maine	970,000
Ohio	933,000
Illinois	856,000
New York	620,000

* Papers from the Biological Laboratory of the Maine Experiment Station, No. 18.

Wisconsin	343,000
Indiana	301,000
Minnesota	124,000
Tennessee, Oklahoma, Kansas, Missouri, Delaware, Pennsylvania and Michigan together	246,000
All other states	291,000
Total	6,779,000

From these figures it appears that Maine stood third among all the states in the amount of sweet corn packed in 1908. The figures given are for cases of 2 dozen cans each. On this basis the Maine sweet corn pack for the year 1908 amounted, in round numbers, to the enormous total of 23,280,000 cans!

While the sweet corn packing industry has grown to the magnitude indicated in the figures given, it still remains a somewhat hazardous and precarious business, in which both the farmer and the packer are at times compelled to take great risks, and too often to bear heavy losses. The climatic conditions in Maine are the chief source of risk in the business. The growing season to be expected at best is dangerously close to the minimum time necessary to grow good corn. When to this are added the risks arising from the occurrence of late spring and early fall frosts, together with an uncertain distribution of rainfall during the growing season it is evident that there must always be a considerable element of uncertainty as to whether, on the one hand, the farmer who plants sweet corn will get enough out of his crop to pay for seed and fertilizer, and, on the other hand, the packer will be able to produce the number of cans required to fill his contracts.

In view of these considerations it seemed desirable for the Experiment Station to undertake a study of some of the problems connected with the sweet corn industry, with a view to the possibility of being able to help both the farmer and the packer. After looking over the whole field it appeared that the seed problem was one particularly needing attention. The major portion of all the sweet corn grown in Maine is from seed produced outside the state, chiefly in Massachusetts and Connecticut. The seed is for the most part not specially se-

lected or bred to meet the conditions in Maine. Almost the only selection which it undergoes is that of the market. If a lot of sweet corn seed offered for sale is not of the type the packer wants he does not buy it. The packers have great difficulty in procuring sweet corn seed which is satisfactory either to themselves or to the farmers who plant for them. The distribution and entire control of the seed is, and must always continue in general to remain, in the hands of the packers. The farmer sometimes complains bitterly of this, particularly after he has had a lot of poor seed, as too frequently happens. But a moment's consideration must convince one that it would be a suicidal policy for the packer to allow his farmers to plant any kind of seed they pleased. All uniformity of product in the first place, and possibility of economical operation of the canning factory in the second place would be forthwith greatly endangered, and in a short time entirely lost. The farmer must recognize that it is as much to the interest of the packer as to his own that he have good seed. It is the misfortune rather than the fault of the packer that he does not always get it.

The primary aim with which the experiments here discussed were undertaken was to determine whether it was not possible, by the application of simple methods which could be used by any packer or farmer, to improve Maine grown sweet corn and adapt it more closely to the needs imposed by local conditions. It was felt that the broad generalization of plant breeding to the effect that a seed bred in adaptation to local conditions is, on the average, likely to give better results under those conditions than an imported seed is probably true of sweet corn. Subsequent experience has shown that it is. The best sweet corn grown in the State today is the product of Maine grown seed. The second aim of the work was to accumulate scientific data regarding the inheritance of various characters of the maize plant.

The work with sweet corn was begun in the summer of 1907 and has continued since that time. It is believed that the work which has been done has demonstrated the primary thing for which it was started. It has, namely, shown that it is possible by the use of a few simple methods, easily under the control of the packer, to improve in several respects the quality of the average seed corn distributed to the farmers by the packers.

This is all that it was hoped or expected to do. The Station cannot enter upon the commercial breeding of improved sweet corn seed. It can only point out methods by which such breeding may be done by others.

It is the purpose of this bulletin to give a brief account of the general features of the experiments carried on during the past three years in sweet corn breeding. Further discussion of the technically scientific results of this work is reserved for later publication.

Existing and Desired Types of Sweet Corn in Maine.

Practically all of the sweet corn grown in Maine for canning purposes belongs to one or the other of two general types. Representative strains of these two types are grown under different names in different localities. We have accordingly come to pay little attention to the varietal names of sweet corn, in this work. The two main types under which the corn may be grouped are characterized in the following way:

Type I.—A pure white corn, with *small kernels* closely packed on the cob. The number of rows varies from 14 to 22, with an average of 16 to 18. The corn makes a rapid growth and matures relatively early. The stalks, on good land and in a good season, will vary from 5 to 6 feet in height, with an average of from 5 to 5½ feet. The yield of stover is only fairly good, but the yield of ears is usually very good. The ears are shorter than in the case of Type II, and in some strains are well shaped. In other strains the ear, owing to lack of selection probably, tapers very much. Of this type of corn the best is undoubtedly that produced by the so-called Dennett and Ellis strains. These two strains, which, so far as we are able to discover by study both of the growing corn and of the seed, differ very slightly except in name, have for many years been grown for seed in the region around Brownfield, Me. Accounts differ as to the detailed history of these strains, but all agree that this type of sweet corn came into the Brownfield region many years ago (15 to 25?) as a small sample of ears. In recent years there has been no inter-mixture of any other type of sweet corn in this region. On the Dennett and the Ellis farms the same seed has been used year after year without any introduction of "new blood," and without any detasseling to insure

cross fertilization. As a consequence of this practice these strains can only be regarded as very closely inbred. That their yield has not been unfavorably affected is a point of interest. In the propagation of both of these strains on the original farms a very careful *ear* selection is practiced. There has never been any *plant* selection in the case of either of these strains so far as we can learn. Both strains produce a remarkably uniform corn. The breeder who expects to find and isolate wide deviations from type in the case of the pure Ellis or Dennett strains will be disappointed.

Type II—A white corn, frequently showing a faint yellowish tinge, with kernels *larger* and *coarser* than those of Type I, and not so tightly packed on the cob. The number of rows averages lower than in Type I. The ears are longer. The rate of growth and time of maturity vary greatly in different strains. Some are nearly as early as the best of Type I. Others are very late. The stalks are larger and yield more stover than in the case of Type I. The yield of ears, or of cut corn at the factory is usually not so large per unit area of land. The ears are in many strains coarse and ill-shaped, but some strains give ears of high quality. This type of sweet corn is highly popular with the farmer, because of its greater yield of stover. This circumstance has led to its wide adoption by the packer, though from his standpoint it is not so desirable a corn as Type I. In the opinion of the writers the popularity of this coarser type of corn with the grower is not altogether well judged. The farmer, to be sure, gets more fodder from it than from the other type, but he really pays a rather high price for it in decreased yield of ears. This was brought out in a striking manner in connection with some inquiries as to what was considered in different localities a very good to maximum money return per acre of sweet corn. In localities where good strains of Type I corn were the prevailing sort planted it was not difficult to find farmers who, under favorable conditions as to season, etc., had obtained a return of $100 or a little more per acre of corn. In localities where the prevailing kind planted was of Type II we were not able to learn of anyone ever having had a better return than $80 to $85 per acre, the price per pound of cut corn at the factory being the same in both localities. About the same proportionate difference would doubtless be main-

tained with smaller yields. Such a difference represents a rather high price for the fodder from an acre. Typical varieties of corn of this second type are early and medium Crosby, Clark's Medium, etc.

Typical ears of the two types of corn are shown in Fig. 220. These are ears from the 1907 selections(see below). Ear No. 134 is an excellent Dennett ear (Type I). The point in regard to which it is most at fault is the straightness of the rows. It will be noted that they are somewhat curved in this particular ear. Ear No. 381 is a typical early Crosby ear (Type II). The butt is not perfect but the ear as a whole represents this type of sweet corn very well. The reduction of size in photographing is the same for the two ears. They are 5/8 natural size. It is of interest to compare the various characters of these two ears as given quantitatively in tables 1 and 2. Ear 134 has 18 rows, while 381 has but 16. Ear 381 is 2 cm. longer than 134, yet it has but 33 kernels to the average row while 134 has 36. In spite of its larger size ear 381 produced less than 4 grams (equal to about 1/8 of an ounce) more shelled corn than 134.

When the work of the Station with sweet corn was being planned a meeting was arranged between representatives of the Station and of the principal packing interests in the State. The purpose of this meeting was to learn what the packers regarded as an ideal sweet corn for their uses, and in what particulars they felt that the best existing strains needed improvement. As a result of this conference the following points were brought out as of first importance in an ideal sweet corn for canning purposes: 1. Pure white color. 2. Small kernels, giving what is technically termed a fine grained ear. 3. Good flavor and sweetness. 4. Ear of good size, cylindrical rather than tapering in shape, and with butt and tip evenly covered. 5. Rows straight and at least 16 in number. A higher number is desirable in order to get the fineness of kernel. 6. Good yield both of ear corn and of stover. 7. Uniformity of ear type. 8. Early maturity.

The best of the sweet corn grown in the State meets certain of these ideals fairly well. The points in regard to which improvement was regarded by the packers as most needed were (a) earliness, (b) yield, particularly of stover, and (c) con-

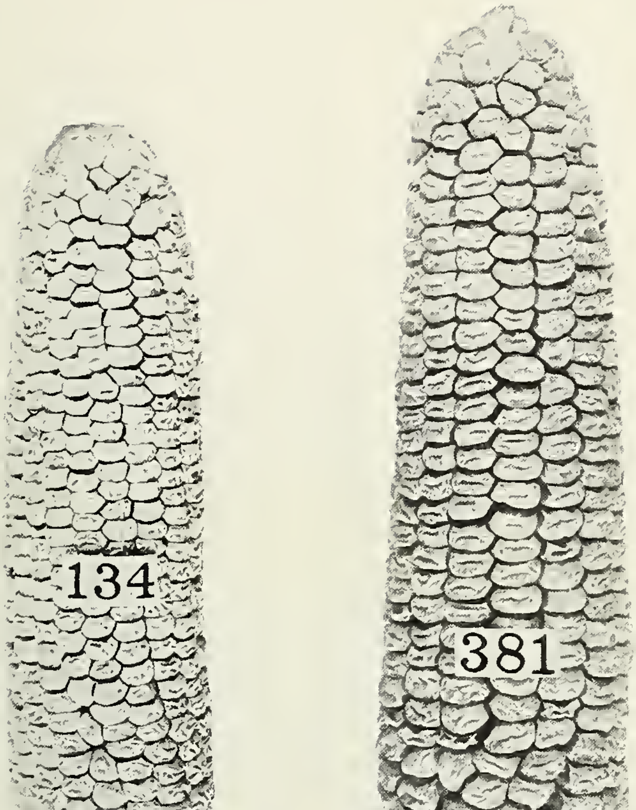


FIG. 220. Representative ears to illustrate the two types of sweet corn (I and II) discussed in the text. Ear 134 is of type I, and ear 381 is of type II. Five-eighths natural size.

formation of ear, especially with reference to shape and covering of tip. The earliness was regarded by all concerned as the most important single point needing improvement.

Accordingly in the summer of 1907 experiments in the improvement of sweet corn in regard to these characters by selection were inaugurated. As already stated it was desired to carry through such selection work in the simplest manner possible, so that in the event of favorable results the same processes could be repeated by any packer or grower. The general plan it was proposed to follow was that of making field selections of plants with reference to the desirable qualities, and then in the following year planting the selected ears on the ear-to-row system which brings the progeny of a single mother ear together in the same row. Advice was sought from some of the leading packers as to localities in which what they regarded as the best corn was grown, so that selection might be started there.

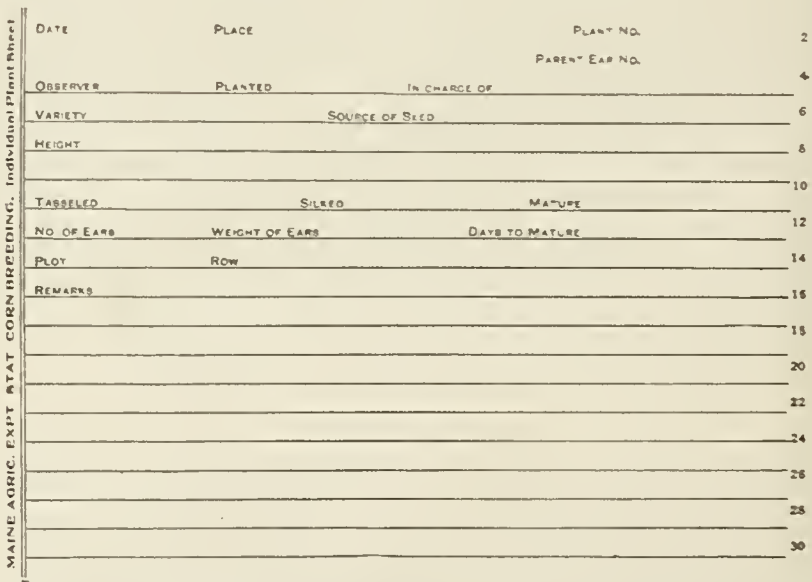
Throughout this work the Station has been greatly indebted to the corn packers of the State for their hearty co-operation, which has made it possible to carry on the investigation in a more advantageous way than would otherwise have been the case. In particular it is desired in this connection to express the gratitude of the Station to the following companies and individuals: The Burnham & Morrill Co., The Portland Packing Co., Fernald, Keene and True Co., The Monmouth Canning Co., H. F. Webb Co., The Saco Valley Canning Co., the United Packers, Mr. F. F. Noyes, Minot Packing Co., and Mr. A. F. York. Also we wish to express our thanks to Mr. J. H. Heath of Farmington, on whose farm all of the sweet corn work except the making of some of the original field selections has been done. Mr. Heath's long experience and skill as a sweet corn grower have been invaluable aids in the work.

Work in 1907.

Late in August 1907 the writers began the field selection of sweet corn. Selections were made from varieties of both Type I and Type II as defined above. The Type I selections were made at Farmington and were from Dennett and Ellis strains. The Type II selections were made at Newport and Dexter and were from early and medium Crosby strains.

In making the field selections earliness was taken as the character of primary importance. This was judged from a variety of characteristics. At the time the first selections were made of the Type I corn, (August 29, 1907) the silks on the earliest plants were dead and thoroughly dried. On many plants in the field, however, the silks were still perfectly green. The stalks and leaves were in all cases still green. Only on the exceptionally early plants had the husks begun to dry out at their ends. All of these points, as well as the condition of the ear itself, were taken into account in judging of the degree of earliness. All plants which appeared especially early, and not absolutely defective in other qualities were marked with a tag bearing a number. In order to make such tagged plants more readily distinguishable in the field there was tied around the top of each stalk a narrow streamer of red cheese cloth.

The number on the tag was the individual plant number by which that plant could at any time afterward be identified in the records. No individual plant number is ever duplicated in the selection work. Notes were taken at the time of the original selection of each plant. These notes were recorded on 5″ x 8″ loose leaf sheets like that shown in facsimile in Fig. 221.


MAINE AGRIC. EXPT STAT CORN BREEDING. Individual Plant Sheet

DATE PLACE PLANT NO.
PARENT EAR NO.
OBSERVER PLANTED IN CHARGE OF
VARIETY SOURCE OF SEED
HEIGHT
TASSELED SILKED MATURE
NO OF EARS WEIGHT OF EARS DAYS TO MATURE
PLOT ROW
REMARKS

2 4 6 8 10 12 14 16 18 20 22 24 26 28 30

Fig. 221. Facsimile of individual plant record sheet used in corn breeding work.

In addition to the data provided for on the blank, records were taken regarding the number of suckers associated with the plant, the stover qualities of the plant (breadth of leaf, etc.) and any other points thought likely to be of interest subsequently. About 400 individual plants were selected in the manner described during the latter part of August and the first half of September 1907. The general crop of Dennett corn (Type I) at Farmington from which the bulk of the selections of that type were made was hauled to the factory for canning September 12, 1907, and the next few days following. This corn was planted May 18, 1907. The selected plants were allowed to stand and ripen, and were harvested for seed September 26 and 27. But for bad weather the seed could have been harvested a few days earlier. The selected seed of the Crosby varieties (Type II) taken at Newport and Dexter was harvested October 9 and 10, 1907, respectively. The corn at Newport was planted June 4, 1907, and that at Dexter* June 12, 1907. The selected seed ears after harvesting were shipped by express to Orono, and placed on racks in such way that no kernel on any ear was in contact with anything but the air. These racks were placed in the attic of the Station building and the corn was dried at an average temperature of 65° to 75° with some circulation of the air all the time. As will be seen from the germination figures in table 1 below, the seed was satisfactorily cured in this way.

Unfortunately, owing to a misunderstanding, a considerable number of the selected plants in the Dennett plot at Farmington were harvested and lost at the time the general crop was cut for the factory. Through the kindness of Mr. J. H. Heath, on whose farm this corn was raised, it was possible to replace these lost ears by ears which he had himself selected for seed in the same field. His selection, like ours, had been in considerable degree on the basis of earliness. Of course, however, it was not possible in the case of these ears to get any data regarding the original plant on which they grew.

After being thoroughly dried the ears were taken from the racks and subjected to careful study to determine their avail-

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*The field selections at Newport were made on the farm of Mr. Henry S. Thorne: those at Dexter on the farms of Mr. Fred O. Addition, and Mr. John Marsh. To all of these gentlemen we are indebted for their hearty cooperation in this work.

ability for planting. In other words, a second selection was practiced. The first selection had been primarily on the basis of earliness. All the seed harvested (with the exception of the substitute ears already referred to and others taken for particular experimental purposes) was known to have matured earlier than the general average. The second selection was for the purpose of picking out the most desirable of these early ears. In order to put the selection on a quantitative basis, instead of mere general appreciation of quality, the following data were collected for each thoroughly air-dried ear: (a) weight of ear in grams, (b) number of rows, (c) number of kernels in average row, (d) the circumference of the ear one inch from the butt, taken in mm. with a steel tape, (e) the circumference in mm. of the ear one inch from the tip, (f) the circumference in mm. of the cob one inch from the butt, (g) the circumference in mm. of the cob one inch from the tip, (h) the weight of the cob in grams, (i) the length of the ear in cm., and (j) the net weight of shelled corn from the ear. The butts and tips of the ears back a distance of 1 inch from each end were shelled separately from the rest of the ear, and only the kernels from the body of the ear used for seed. The germination of each ear was tested in a Geneva tester, on a random sample of 25 kernels.

The records of these data were made upon loose leaf blanks of the sort shown in facsimile in Fig. 222.

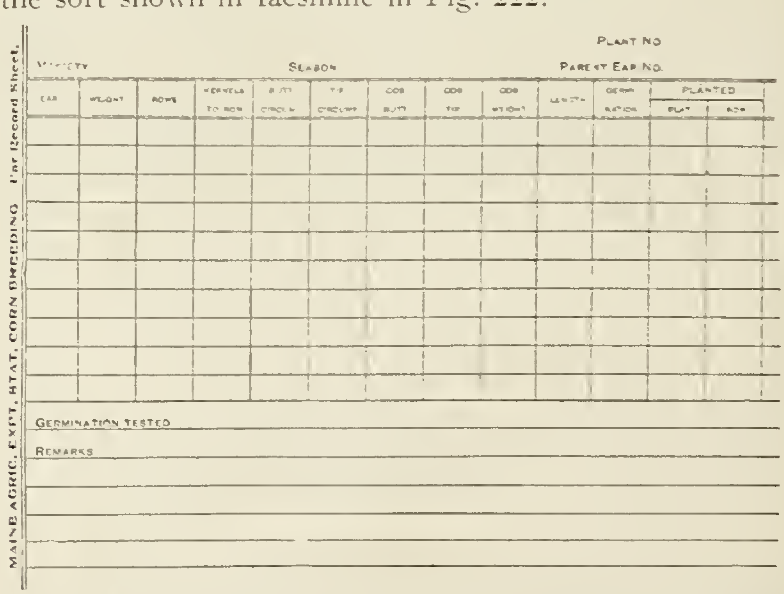

Fig. 222. Facsimile of blank used for the recording of ear characters in sweet corn breeding work.

The data on the ears finally chosen for planting in 1908 of each of the two types are given in tables 1 and 2.

TABLE I.

Data on Ears Selected in 1907 for Planting in 1908. Type I.

Ear No.	Weight in grams.	Rows.	Kernels to row.	Butt circumference in cm.	Tip circumference in cm.	Cob butt circumference in cm.	Cob tip circumference in cm.	Cob weight in grams.	Length in cms.	Net weight of shelled corn in grams.	Germination.	Planted row No.
1.......	102.0	18	36	13.2	10.4	9.7	7.0	21.90	16.4	80.10	100	165
5.......	105.0	16	33	14.8	11.4	9.8	7.2	22.45	16.3	82.55	100	166
6.......	98.0	20	33	14.8	12.6	10.5	8.5	18.00	14.0	80.00	100	174
7.......	84.5	20	38	13.1	11.3	9.2	7.2	17.65	16.5	66.85	100	195
8.......	111.0	18	38	13.9	10.0	9.3	6.3	20.25	16.5	90.75	100	169
9.......	81.0	14	33	13.3	11.3	9.4	7.3	15.85	14.3	65.15	96	149
10.......	106.0	16	36	14.6	11.3	10.0	7.5	22.85	16.7	83.15	100	104
11.......	106.0	18	38	14.8	11.7	9.3	7.5	21.35	16.0	84.65	100	107
12.......	102.0	16	33	13.7	12.5	9.3	7.9	21.50	15.2	80.50	100	121
13.......	80.0	16	30	13.4	10.8	9.4	7.0	14.70	13.0	65.30	100	136
16.......	104.5	20	38	14.3	10.8	9.6	6.9	17.45	14.0	87.05	100	108
17.......	107.0	18	34	13.7	11.7	9.4	7.5	20.30	16.8	86.70	100	173
21.......	109.0	16	38	14.8	11.8	10.2	7.8	21.80	15.8	87.20	100	109
22.......	107.0	16	35	13.7	11.1	10.0	7.0	22.30	17.9	84.70	100	117
23.......	98.5	22	25	15.1	13.5	10.4	8.7	18.60	11.0	79.90	96	124
24.......	87.5	18	35	13.2	12.0	9.8	7.7	20.45	16.0	67.05	96	133
29.......	109.0	18	34	14.8	11.2	10.0	7.3	20.90	15.5	88.10	100	167
33.......	114.0	14	38	14.8	11.9	10.0	7.4	25.40	16.5	88.60	100	168
34.......	98.5	16	27	13.2	11.0	9.3	7.6	18.30	15.3	80.20	96	122
35.......	95.2	14	37	14.1	11.2	10.1	7.4	22.50	16.0	72.70	96	151
36.......	97.0	18	32	13.3	11.1	9.5	7.4	20.00	15.4	77.00	100	126
38.......	78.5	16	34	13.1	11.0	9.4	7.0	16.50	14.0	62.00	100	142
39.......	96.0	16	34	13.6	11.0	9.1	7.5	19.70	15.3	76.30	100	128
40.......	117.7	20	36	15.2	12.0	11.0	7.3	25.40	16.8	92.30	96	112
41.......	104.0	18	32	14.3	11.8	10.3	8.1	20.65	15.5	83.35	92	118
42.......	81.0	20	32	13.5	12.9	9.5	8.3	17.40	15.5	63.60	100	194
45.......	92.0	16	34	13.6	9.5	9.1	6.5	16.60	14.1	75.40	92	175
46.......	93.5	18	34	14.5	12.0	10.0	7.7	25.25	15.2	67.25	84	196
47.......	122.0	18	34	15.2	12.3	10.6	8.0	22.30	17.0	99.70	98	114
48.......	104.0	16	38	14.2	11.7	9.5	7.5	22.00	15.2	82.00	100	102
49.......	88.4	16	34	14.0	11.5	9.6	7.9	17.95	14.2	70.45	100	187
50.......	125.0	18	37	14.7	11.8	10.2	7.8	25.50	16.2	99.50	96	113
51.......	99.5	20	35	13.6	12.1	9.8	8.3	21.95	15.4	77.55	100	161
58.......	96.8	16	32	13.5	12.0	9.7	8.0	22.20	15.6	74.60	96	155
59.......	97.0	20	36	14.4	12.0	10.2	7.6	22.00	16.0	75.00	100	154
60A.....	76.0	14	34	13.5	10.8	9.3	7.4	14.90	13.6	61.10	100	178
60B.....	92.8	20	29	14.1	12.9	9.9	8.8	19.10	13.5	73.70	100	176
62.......	98.2	20	35	13.7	10.1	10.0	7.2	20.75	16.5	77.45	100	157
64.......	96.5	18	33	14.2	10.2	10.0	7.0	21.20	17.0	75.30	100	153
67.......	85.0	16	26	13.9	11.3	9.8	7.5	18.00	14.0	67.00	88	182
68.......	114.7	20	37	14.1	12.5	10.2	8.5	22.65	15.7	92.05	100	172
72.......	90.0	16	35	13.5	11.0	9.5	7.7	22.50	16.0	67.50	88	197
78.......	89.0	18	36	13.2	11.0	9.2	7.5	21.10	16.3	67.90	100	192
110.......	90.5	18	35	14.8	10.5	10.5	7.3	19.15	15.0	71.35	100	132
113.......	102.5	16	33	13.9	11.7	10.0	8.1	21.60	15.5	80.90	92	101
115.......	86.5	18	36	13.4	10.6	9.1	7.1	18.50	14.5	68.00	92	193
116.......	85.5	16	31	13.6	11.0	9.7	7.1	16.90	14.4	68.60	100	189
125.......	94.5	16	33	14.0	11.0	9.3	6.8	20.25	16.3	74.25	100	152
127.......	84.0	18	34	12.9	10.5	9.2	7.5	17.50	15.0	66.50	100	198
128.......	72.5	16	30	14.7	11.0	9.2	7.5	15.75	12.5	56.75	96	141
129.......	80.0	18	35	13.5	11.3	9.8	7.1	17.65	13.5	62.35	96	147

TABLE 1—Concluded.

Ear No.	Weight in grams.	Rows.	Kernels to row.	Butt circumference in cm.	Tip circumference in cm.	Cob butt circumference in cm.	Cob tip circumference in cm.	Cob weight in grams.	Length in cms.	Net weight of shelled corn in grams.	Germination.	Planted row No.
130.......	87.5	16	35	13.7	11.2	9.4	7.0	18.25	14.5	69.30	100	190
132A.....	101.5	18	35	14.4	10.6	10.6	7.8	22.80	15.5	72.7[illegible]	100	177
132B.....	84.0	16	40	13.5	11.2	9.5	7.4	25.50	16.5	58.50	100	179
133.......	88.0	16	34	14.2	11.4	10.3	7.7	20.70	15.8	67.[illegible]	100	199
134.......	94.6	18	36	12.7	11.2	8.5	7.0	16.80	14.0	77.80	100	160
136.......	89.7	18	32	13.9	11.4	10.0	7.8	20.75	14.8	68.95	100	191
137.......	101.3	20	36	14.0	11.5	10.0	7.7	22.95	16.[illegible]	78.[illegible]	100	158
138.......	105.8	16	38	14.2	10.8	10.2	7.3	24.5[illegible]	17.2	82.[illegible]	96	1[illegible]
139.	79.0	16	30	13.2	11.5	9.1	7.6	17.10	1[illegible]	61.[illegible]	100	146
141.......	89.5	16	39	12.7	11.4	8.5	7.0	19.10	16.[illegible]	7[illegible].40	100	188
143.......	88.5	18	32	14.3	12.4	10.3	8.0	21.65	14.5	[illegible]	100	1[illegible]
144.......	82.0	16	33	13.2	10.2	9.2	6.8	17.25	15.3	64.25	100	148
147.......	94.5	16	39	14.0	11.5	9.5	7.3	18.[illegible]	14.4	75.8[illegible]	100	17[illegible]
148.......	81.5	18	29	13.3	11.7	9.3	7.7	16.[illegible]	17.2	65.[illegible]	100	1[illegible]4
149.......	82.5	16	35	13.4	11.9	9.3	7.2	17.55	14.[illegible]	64.95	100	1[illegible]5
151.......	91.3	16	35	13.7	11.1	9.2	7.2	19.[illegible]	15.0	71.80	97	18[illegible]
154.......	82.5	20	32	13.6	11.6	10.[illegible]	7.8	18.10	15.[illegible]	64.4[illegible]	96	117
157......	113.0	18	39	14.6	1[illegible].8	10.0	7.0	24.45	17.[illegible]	88.[illegible]	97	111
160......	93.0	18	35	14.1	10.8	10.[illegible]	6.7	[illegible].55	13.8	79.2[illegible]	100	1[illegible]
162.......	106.5	22	37	14.3	11.5	10.[illegible]	7.6	24.[illegible]	17.8	[illegible]	100	1[illegible]
164.......	81.0	20	37	13.5	10.6	10.0	7.[illegible]	21.[illegible]	1[illegible].8	[illegible]	100	1[illegible]
165.......	71.5	16	28	13.8	11.9	9.[illegible]	7.5	14.65	12.8	56.8[illegible]	100	158
167.......	98.3	18	36	14.9	11.9	10.5	7.3	19.7[illegible]	17.4	78.[illegible]	100	1[illegible]
168.......	75.8	16	34	12.7	9.9	9.0	6.7	17.10	1[illegible].7	58.7[illegible]	100	14[illegible]
169.......	75.0	16	32	12.8	11.0	9.0	7.[illegible]	15.6[illegible]	14.2	[illegible].40	100	144
170......	77.0	16	27	13.4	12.7	9.7	8.4	17.[illegible]	11.5	[illegible].50	100	1[illegible]
171......	90.5	22	34	1[illegible]	11.[illegible]	9.[illegible]	7.6	18.[illegible]	15.2	72.[illegible]	100	1[illegible]
172......	76.5	18	29	12.8	11.0	9.0	7.8	15.[illegible]	14.0	61.[illegible]	96	184
173.......	108.0	16	42	13.8	11.7	9.7	7.8	24.40	17.5	83.6[illegible]	100	1[illegible]
174.......	85.0	16	38	12.9	10.5	9.1	6.9	19.[illegible]	15.5	65.7[illegible]	100	150
176.......	99.5	20	35	14.5	11.5	10.6	8.[illegible]	21.4[illegible]	17.7	78.1[illegible]	92	1[illegible]
177.......	100.0	16	35	1[illegible].4	11.5	9.3	7.4	19.6[illegible]	1[illegible]	[illegible]	100	164
178.......	77.5	18	36	13.0	11.3	8.8	7.0	14.[illegible]	14.[illegible]	[illegible]	100	14[illegible]
180.......	73.5	16	30	12.6	11.4	8.6	7.4	16.8[illegible]	12.[illegible]	56.7[illegible]	96	14[illegible]
187.......	110.5	20	40	14.0	11.2	9.2	7.[illegible]	23.1[illegible]	19.[illegible]	87.[illegible]	92	116
193.......	87.5	16	30	14.7	11.7	9.3	7.4	15.0[illegible]	12.[illegible]	72.5[illegible]	100	1[illegible]1
194.......	126.0	20	35	16.1	12.1	11.3	8.0	28.[illegible]	16.[illegible]	97.1[illegible]	100	170
198.......	85.0	16	32	13.6	10.7	9.8	7.2	20.10	1[illegible]	64.[illegible]	100	1[illegible]
199.......	88.0	18	37	13.6	10.3	8.5	6.1	13.6[illegible]	17.[illegible]	74.4[illegible]	84	1[illegible]
201B	105.0	20	27	16.2	13.2	11.5	8.7	21.6[illegible]	12.5	83.4[illegible]	96	120
204.	96.0	16	36	14.4	11.[illegible]	9.5	7.0	19.1[illegible]	16.0	76.9[illegible]	100	127
206......	90.8	20	29	14.6	11.5	9.0	6.0	14.45	14.2	76.[illegible]	72	181
216.......	98.5	18	38	13.7	10.8	9.4	7.5	24.10	17.0	74.4[illegible]	100	130
217.......	107.5	20	38	14.4	12.5	9.7	8.0	24.45	17.0	83.05	100	119
218.......	99.0	20	36	14.0	12.4	9.8	6.7	20.50	16.0	78.5[illegible]	100	123
222.......	141.5	18	36	15.3	11.4	11.0	7.0	29.2[illegible]	18.0	112.3[illegible]	100	115
223.......	120.0	16	38	14.4	11.6	9.5	6.4	22.70	16.7	97.3[illegible]	100	171
225.......	97.0	16	33	13.6	11.4	8.7	7.5	17.70	13.5	79.30	96	125
227.......	110.5	16	40	14.5	11.0	10.0	7.1	21.75	15.0	88.75	100	11[illegible]
Averages	95.26	17.50	34.32	13.92	11.39	9.68	7.43	20.08	15.22	75.22	97.94	

TABLE 2.

Data on Ears Selected in 1907 for Planting in 1908. Type II.

Ear No.	Weight in grams.	Rows.	Kernels to row.	Butt circumference in cm.	Tip circumference in cm.	Cob butt circumference in cm.	Cob tip circumference in cm.	Cob weight in grams.	Length in cms.	Net weight of shelled corn in grams.	Germination.	Planted row No.
82.......	103.0	14	31	14.2	11.8	9.8	7.8	23.20	15.3	79.80	96	228
83.......	112.0	16	36	14.5	10.9	9.1	6.9	23.20	16.5	88.80	100	217
84.......	100.5	18	32	15.6	12.5	10.7	7.6	23.95	15.0	76.55	100	204
86B.....	95.2	14	33	15.8	12.2	10.5	7.2	19.75	12.5	82.70	80	227
87.......	104.5	18	33	15.4	12.1	10.9	7.5	25.90	16.0	78.60	92	229
88.......	105.0	16	33	14.6	11.3	10.7	7.5	28.45	15.6	76.55	96	203
91.	128.5	18	36	15.4	12.8	10.5	7.6	33.35	17.3	95.15	100	222
93.......	114.0	16	35	14.7	12.0	10.0	7.3	22.90	16.0	91.10	100	219
98.......	101.5	16	33	15.4	12.0	10.5	8.3	26.95	14.5	74.55	100	245
100.......	100.0	16	33	14.6	13.0	9.8	7.9	24.75	15.5	75.25	96	246
105.......	94.7	16	30	15.7	12.1	10.5	7.9	19.15	13.1	75.55	96	231
106.......	121.5	18	34	15.7	12.7	11.0	7.9	28.80	15.7	92.70	100	221
107.......	87.6	16	33	14.6	12.3	9.8	7.5	19.30	14.5	68.30	100	237
231.......	94.7	16	33	13.7	11.3	9.5	7.5	20.75	15.2	73.95	92	241
235.......	95.0	20	33	14.7	13.0	10.2	8.0	23.45	12.3	71.55	96	254
236.......	89.0	18	31	15.0	12.6	10.8	7.5	20.90	13.7	68.10	100	261
241.......	88.5	16	33	14.5	12.0	10.0	7.9	21.85	13.4	66.65	100	264
242.......	88.8	16	33	14.7	12.6	9.5	8.0	20.25	16.6	68.55	96	257
247.......	109.0	16	31	15.7	12.7	11.2	8.5	27.40	15.5	81.60	96	209
257.......	94.0	18	33	15.0	11.9	10.7	8.4	26.15	14.6	67.85	96	238
258A.....	84.3	12	30	13.8	12.5	9.5	7.6	19.70	15.4	64.60	88	239
258B......	82.5	16	26	14.2	13.1	9.6	8.2	17.70	12.8	64.80	96	240
265.......	91.5	16	31	15.5	13.0	11.0	8.3	22.40	12.8	69.10	92	258
274.......	89.5	18	33	14.9	10.6	11.0	6.8	23.40	15.8	66.10	76	265
287......	98.0	18	30	14.9	12.7	10.5	8.0	24.00	14.4	74.00	88	247
292.......	92.5	16	33	14.3	11.5	9.8	7.7	20.80	14.1	71.70	96	253
295.......	99.5	18	33	15.1	11.7	11.0	8.0	26.10	14.8	73.40	100	249
296.......	92.0	14	34	14.0	11.1	9.9	7.0	22.10	18.0	70.90	98	235
303.......	95.5	16	33	14.2	11.1	10.0	7.0	23.80	17.0	71.70	100	252
304.......	103.0	16	33	15.7	13.0	10.0	7.9	24.85	15.3	78.15	100	205
307......	90.0	16	33	14.9	11.8	9.4	7.4	21.55	14.3	38.45	100	262
317.......	102.5	18	33	16.5	13.5	10.6	8.6	26.55	14.5	75.90	100	244
319.......	92.0	20	28	15.4	12.2	10.9	8.1	22.95	14.0	69.05	100	259
329.......	95.5	16	30	14.2	11.9	10.0	7.2	22.90	14.0	72.60	96	250
333.......	117.0	14	37	14.5	11.1	9.4	7.5	27.70	18.1	87.30	92	214
337.......	95.5	20	31	15.2	12.0	11.3	8.3	22.80	14.2	72.70	92	251
338A.....	94.0	16	29	14.1	11.8	9.8	7.5	21.45	14.7	72.55	96	232
338B......	78.8	16	24	13.0	12.0	9.0	7.4	17.25	12.5	61.55	100	233
339.......	88.3	16	30	14.5	12.7	9.8	8.0	19.30	13.9	69.00	88	260
343.......	106.0	14	34	14.6	11.0	10.2	7.2	22.15	17.8	83.85	100	212
346.......	103.5	16	36	15.0	12.3	9.8	7.3	22.45	15.0	80.55	88	208
350.......	103.5	16	33	14.6	11.2	9.7	7.3	22.55	17.2	80 95	100	242
355.......	116.0	16	36	15.3	11.6	10.7	7.4	18.50	16.0	97.50	100	223
357.......	116.5	14	33	15.3	12.9	10.1	8.0	26.55	17.4	89 95	92	218
359.......	94.3	12	35	13.5	11.4	9.0	7.0	19.95	15.0	74.35	96	248
361.......	107.3	18	36	14.9	10.7	9.8	6.2	20.50	16.0	86.80	100	213
364.......	103.0	12	33	13.8	11.5	9.0	7.0	24.00	16.6	89.00	100	224
365.......	119.5	18	35	16.1	13.0	11.1	8.0	31.10	16.5	88.40	92	215
366.......	87.0	16	32	14.0	12.0	8.7	6.8	18.65	15.7	68.35	100	263
370.......	95.0	16	34	14.9	12.6	10.1	8.0	22.70	14.2	72.30	100	234
371.......	92.0	16	30	15.0	12.7	10.3	7.5	21.45	15.3	70.55	100	236

TABLE 2—Concluded.

Ear No.	Weight in grams.	Rows.	Kernels to row.	Butt circumference in cm.	Tip circumference in cm.	Cob butt circumference in cm.	Cob tip circumference in cm.	Cob weight in grams.	Length in cms.	Net weight of shelled corn in grams.	Germination.	Planted row No.
373.......	104.0	24	34	15.7	12.0	10.1	7.5	23.80	15.0	80.20	100	207
375.......	94 0	14	36	15.0	11.5	10.0	6.8	17.45	15.5	76.55	96	202
376.......	103.0	18	37	14.0	11.6	10.0	7.1	26.10	16.0	76.90	96	201
377.......	94.0	16	29	14.7	12.8	10.0	7.7	22.25	15.2	71.75	92	255
381.......	106.5	16	33	14.7	11.9	10.7	7.5	24.80	16.0	81.70	92	211
384.......	86.5	18	29	15.1	12.9	10.6	7.9	21.20	12.2	65.30	100	266
387.......	99.0	14	37	14.4	10.5	9.5	6.4	17.00	16.0	82.00	96	210
393.......	110.5	16	35	14.5	11.4	10.8	7.6	30.75	16.7	79.75	100	206
394.......	120.5	22	36	16.1	13.1	11.5	8.4	27.80	15.1	92.70	96	229
395.......	118.7	14	37	14.7	11.3	10.0	7.8	30.15	16.8	88.55	100	216
396.......	122.0	16	33	15.4	12.6	11.0	8.5	33.60	16.6	78.40	96	230
397A.....	110.5	12	33	15.6	11.8	10.6	7.0	23.60	15.0	86.90	100	225
397B......	95.8	16	29	14.8	13.0	10.1	7.7	21.80	13.5	74.00	96	226
400.......	95.0	16	31	15.1	11.8	10.3	7.2	24.15	14.2	70.85	84	256
Averages	100.19	16.31	32.71	14.85	12.06	10.18	7.60	23.43	15.17	76.85	96	

From these tables the following points will be noted:

1. There is a considerable range of variation in the selected ears. This was intentional. It was desired to have different degrees of each character represented in the ear-to-row test plots.

2. The characteristic differences of the two types of corn are well brought out in these tables. Thus it appears that while the average weight of the ear is about 5 grams greater for the Type II corn than for the Type I. this difference is largely in the weight of the cob in the two cases, rather than in the weight of the grains. The Type II has a bigger cob in proportion to the amount of corn it carries than does the Type I. In the Type I selections the net weight of shelled corn is on the average 70 percent. of the total weight of the ear. Whereas in the Type II ears the net weight of shelled corn is but 77 percent.

3. In the case of these selected ears the mean length is practically identical in both samples. But the mean number of kernels to the average row is 2 more in the Type I than in the Type II. This brings out again in another way the fine grained character of this Type I corn.

All discussion of variation in the characters of the ears tabled is deferred to another place.

In addition to the numerical data comprised in Tables 1 and 2, other matters not easily taken account of quantitatively were considered in making selections. These included such things as the straightness of the rows, covering of tip and butt, color of grain, shape of kernel, etc.

Work in 1908.

In the spring of 1908 the 165 selected ears obtained from the 1907 work were planted at Farmington. Each type of corn had a plot to itself, so located that there was no risk of a transference of pollen from one to the other. These plots were also so located as to reduce to the lowest possible degree the likelihood of foreign pollen from neighboring farms fertilizing this corn. As a matter of fact there is no reason to suppose that any crossing did occur. These plots were planted on the farm of Mr. J. H. Heath, who also attended to the cultivation of the corn during its growth. Throughout the growing season of 1908 one of the writers (F. M. Surface) was in the field studying the growth and other matters connected with this corn.

Plot I was planted with the Type I (Dennett and Ellis) seed. This plot was located on bottom or "intervale" land lying contiguous to the Sandy River to the west of Mr. Heath's house. The Type II seed (Crosby) was planted in Plot II. This plot was on upland ground, and was located east of Mr. Heath's house and directly in the rear of the Burnham and Morrill corn factory. The soil in both plots was a light sandy loam, of the type best adapted for the growing of sweet corn, and was in an excellent condition as regards natural fertility. Plot I in 1907 was in the grass period of a regular rotation practiced by Mr. Heath. An excellent crop of hay was raised from the field of which this corn plot was a part in that year. Plot II was in potatoes in 1907. On Plot II a heavy dressing of barnyard manure was plowed under in the fall of 1907. Because of the risk of a spring overflow of the Sandy River it was not advisable to do this in the case of Plot I. That plot was well manured and plowed in the spring of 1908. Both were thoroughly harrowed and had a good seed bed prepared. Deeper harrowing would have been of benefit in the case of Plot I.

The size of Plot I was 300 x 150 feet, or, after allowing for paths, etc., there was exactly one acre in sweet corn. In Plot II the dimensions were 200 x 200 feet. Plot I included 100 rows. The rows ran approximately east and west and were in two sections, 50 rows in each. A path two hills wide was left in the middle of the field between the two sections. Plot II included 66 rows, also running approximately east and west. In both plots the rows were 3 ft. apart, and the hills 18 inches (approximately) apart. On Plot I, 1100 lbs. of Bradley's Corn Phosphate was used, and on Plot II 900 lbs. The fertilizer was applied with a corn planter which dropped it in hills approximately 18 inches apart. The coverers were removed from the planter. This left the fertilizer partially mixed with the soil and exposed in the hill. Then the seed was planted by hand, 3 kernels to a hill. Each row was planted with the seed from one single ear, and a record kept of the ear used for that particular row. Plot I was planted May 19, 1908, and Plot II May 20, 1908. In both plots the seed bed was in excellent condition at the time of planting; the soil was well pulverized, warm and dry. Plot II was a little more moist when planted than Plot I but was not too damp to plant.

On May 28, 1908, the corn in Plot I was coming up nicely; Plot II was not so far along at this time, but scattered hills were up. Plot I gave an excellent even stand. Plot II did not do so well in this regard. Some rows in particular had a number of missing hills. After the corn was well up it was cultivated once a week by running a one-horse cultivator between the rows. It was hoed by hand twice. At the second hoeing, when the stalks were 12-14 inches tall it was thinned so as to leave one plant to the hill. It should not be understood that such a degree of thinning is to be recommended. It was done in this case merely because it was desired to be able to study in detail each individual plant. This can be done most advantageously with only one plant to the hill.

The season of 1908 was a favorable one for growing sweet corn except for the prolonged and severe drought, which was the worst experienced for many years in the part of the State where the experimental plots were located. Fortunately the corn in these plots was not so badly injured as much of that in nearby localities.

The most striking result in 1908 was the marked increase in earliness exhibited in the selected corn of Type I, both in comparison with the same type of corn on the same land the season before, and with other corn of the same type planted in the region about Farmington from factory seed in the same year (1908). The amount of this gain in earliness accompanying one year's selection is indicated by the following figures. The first tassel in Plot I was found July 3, 1908. During the next few days many more appeared. By July 6, 1908, the corn was well tasseled out over the whole plot. The first silk came out on July 14, 1908. In the period July 17-20, 1908, the silk was well out over the whole field. By July 27 and 28, 1908, the silk was drying on a large number of plants. By August 20, 1908, the corn in this plot was as a whole in the proper condition to go into the factory, although a good deal of it was past good canning condition at that date. On August 28, 1908, 180 ears were harvested for seed. These were ears thoroughly matured for seed purposes: stalks dead and dried up. The corn on the whole plot was thoroughly matured and ready to harvest *for seed* September 6, 1908. Harvesting began at that time, and on account of the number of records, etc., to be taken, continued till September 12. No other sweet corn grown in the region about Farmington in 1908 was as early as this selected corn in Plot I, by at least two weeks. In August, 1908, the writers made a rather extended trip through the corn growing region of the southern and western parts of the State. Nowhere was any corn seen which was as early as Plot I at Farmington.

Besides the gain in earliness, there was a marked improvement in the quality of the seed as regards conformation of ear, covering of tip, etc. This was commented upon by all who saw the corn. Some indication regarding this point is given by comparing Figs. 224, 225, 226 and 227, which represent some of the seed ears obtained in 1907 and Figs. 228, 229 and 230, which in the same way show some of the selected ears of 1908.

Plot II did not give as good results as Plot I, in any particular. It compared however, very favorably with the best of the corn grown from factory seed in the region around Farmington. Data regarding the earliness of the corn in this plot are given in the following figures. The first tassel was noted July 8, 1908.

Only a comparatively few plants had tasseled out up to July 14. Silks began appearing July 24 and by July 28 about a half of the stalks in the plot were in full silk. The corn on this plot, with the exception of selected rows saved for seed, was cut and hauled to the factory on September 2. It was then at the proper stage of growth for canning. At this date only a comparatively small amount of corn from factory seed had been brought into the Farmington factory. It was over a week later before the factory began operating at full capacity. The seed ears from selected rows in this plot were harvested for seed September 22, 1908.

From the data given it is evident that the corn in Plot I was much earlier than that in Plot II. A part of this difference is probably to be explained by the innate difference between the two types in regard to this character already noted. Another and perhaps more important factor is to be found in the fact that the Type II corn was in a new environment at Farmington. It was not so well adapted or adjusted to Farmington conditions of soil, climate, etc., as was the Type I corn. This point will be more fully discussed further on.

In the case of the corn on Plot I all of the ears were harvested for seed, the product of each row being of course kept separate. After a preliminary drying at Farmington the corn was shipped to Orono and given a thorough drying on racks in the Experiment Station attic, as described for 1907. After being thoroughly dried the ears from each row were sorted into three classes, A1 seed, good seed and nubbins. The number of ears in each class was counted. Then the ears of each class were shelled and the weight of dry shelled corn from that class determined. These weights were, from necessity, taken in pounds rather than on the metric system. From these was calculated the yield of each row in bushels of corn fit to use for seed per acre. This calculation was made on the assumption that a bushel of dry shelled sweet corn weighs fifty pounds.

The different classes of ears were defined as follows: To be put in the A1 class an ear must have a good butt and a well covered tip, be of good size and shape (nearly cylindrical), have the grains small and well packed and the rows straight. The ears put in this class were of very fine quality. The "good seed" included all other ears which were not undersized or mis-

shapen. No ears were put in this class which would not be graded as good seed ears by a factory distributor or seedsman. The nubbins included all small, malformed or defective ears which could never be used for seed purposes. The "total seed" of the tables below is the sum of A1 and good seed.

The data obtained from this sorting and weighing of the product of the ear-to-row plots are given in Tables 3 and 4, Table 3 dealing with Type I, and Table 4 with Type II corn. In the case of Type II corn only 11 rows were considered of sufficient merit to warrant saving them as a whole for seed. All of the rows of Plot I were saved, though not all were actually used for seed.

The arrangement of data in Tables 3 and 4 is as follows: in the first column is given the number of the row; in the second column the number of the "parent ear" for this row. Thus ear No. 143 was the ear used in planting row No. 100. Detailed data regarding the characteristics of each of the "parent ears" of Tables 3 and 4 are given in Tables 1 and 2 above. The next two main columns give for the A1 seed and good seed respectively the following information: (a) the number of ears falling in the A1 class, (b) the weight (in pounds) of corn shelled from these ears, and (c) the weight of the cobs of these ears. The next main column gives the same information in regard to all ears fit for seed. The figures here are obtained by adding those given in the two preceding columns. The sixth main column of the tables gives the calculated yield of *seed* per acre, based upon the yields in the "total seed" column. The last main column of the tables gives the figures in regard to nubbins and ears too poor to be classed as good seed.

TABLE 3.

Yield of Each Row of Type I Corn in 1908.

Row No.	Parent ear No.	A 1 Seed. No. of ears.	A 1 Seed. Weight of shelled corn in lbs.	A 1 Seed. Cob weight in lbs.	Good Seed. No. of ears.	Good Seed. Weight of shelled corn in lbs.	Good Seed. Cob weight in lbs.	Total Seed. No. of ears.	Total Seed. Weight of shelled corn in lbs.	Total Seed. Cob weight in lbs.	Bushels of seed per acre.	Nubbins. No. of ears.	Nubbins. Weight of shelled corn in lbs.	Nubbins. Cob weight in lbs.
100	143	10	2.13	0.44	78	13.38	3.31	88	15.50	3.75	31.00	31	2.00	0.69
101	113	22	4.31	0.94	130	19.69	4.44	152	24.00	5.38	48.00	27	1.69	0.44
102	48	24	5.00	1.06	93	16.56	3.75	117	21.56	4.81	43.12	61	3.31	1.19
103	138	23	4.13	0.88	104	15.88	4.00	127	20.00	4.88	40.00	66	3.63	1.44
104	10	18	3.56	0.75	72	11.81	2.81	90	15.37	3.56	30.74	53	3.25	1.25
105	173	15	3.06	0.69	84	14.38	3.69	99	17.44	4.38	34.88	44	2.44	1.06
106	162	18	3.44	0.75	92	15.06	3.31	110	18.50	4.06	37.00	59	3.81	1.25
107	11	20	3.81	0.88	64	10.44	2.44	84	14.25	3.32	28.50	49	2.63	1.06
108	16	27	5.88	1.19	94	16.62	3.56	121	22.50	4.75	45.00	47	3.88	1.19
109	21	32	6.25	1.38	79	12.44	2.81	111	18.69	4.19	37.38	53	3.19	1.00
110	227	24	5.31	1.13	64	12.19	2.75	88	17.50	3.88	35.00	48	3.94	1.25
111	157	15	3.06	0.56	115	20.69	4.44	130	23.75	5.00	47.50	46	2.69	0.88
112	40	34	7.31	1.56	70	12.69	3.00	104	20.00	4.56	40.00	50	3.69	1.19
113	50	25	5.25	1.19	75	13.44	2.94	100	18.69	4.13	37.38	28	1.81	0.69
114	47	23	4.31	0.94	78	12.88	2.94	101	17.19	3.88	34.38	33	2.13	0.56
115	222	36	7.00	1.63	92	15.38	3.56	128	22.38	5.19	44.76	34	2.06	0.69
116	187	13	2.44	0.50	73	12.00	2.50	86	14.44	3.00	28.88	45	3.00	0.94
117	22	17	3.44	0.75	87	13.31	2.94	104	16.75	3.69	33.50	43	2.31	0.75
118	41	29	6.06	1.25	67	11.38	2.69	96	17.44	3.94	34.88	47	3.00	1.00
119	217	22	4.50	1.00	79	12.69	2.88	101	17.19	3.88	34.38	36	2.50	0.75
120	201 B	10	2.00	0.44	95	15.69	3.31	105	17.69	3.75	35.38	28	1.94	0.63
121	12	15	3.13	0.63	90	14.31	3.13	105	17.44	3.75	34.88	49	3.00	1.06
122	34	29	6.25	1.38	68	11.50	2.63	97	17.75	4.00	35.50	46	2.63	1.00
123	218	11	3.13	0.69	74	15.00	3.06	85	18.13	3.75	36.26	29	2.13	0.63
124	23	12	2.56	0.50	89	14.56	3.00	101	17.13	3.50	34.26	36	3.56	0.88
125	225	28	5.75	1.19	69	12.19	2.56	97	17.94	3.75	35.88	63	4.93	1.88
126	36	30	6.50	1.50	75	13.19	3.06	105	19.69	4.56	39.38	37	2.44	0.94
127	204	18	3.44	0.69	88	16.13	2.94	106	19.56	3.63	39.12	26	2.06	0.56
128	39	12	2.44	0.44	85	14.56	2.94	97	17.00	3.38	34.00	38	3.00	0.88
129	199	40	9.06	1.44	84	12.44	2.50	124	21.50	3.94	43.00	41	2.63	0.69
130	216	19	3.88	0.56	114	18.25	5.06	133	22.13	5.63	44.26	37	1.81	0.88
131	193	21	4.25	0.88	87	14.63	3.19	108	18.88	4.06	37.76	56	3.06	1.25
132	110	26	5.63	1.13	61	10.81	2.25	87	16.44	3.38	32.88	96	7.06	2.00
133	24	30	7.88	1.75	107	16.13	4.19	137	24.06	5.94	48.12	68	4.13	1.50
134	148	23	4.81	1.00	72	12.69	2.63	95	17.50	3.63	35.00	40	2.75	0.75
135	149	15	2.94	0.63	83	13.00	2.88	98	15.94	3.50	31.88	59	4.00	1.13
136	13	34	7.19	1.44	86	13.75	2.81	120	20.94	4.25	41.88	54	3.50	0.88
137	154	32	6.31	1.38	74	11.25	2.81	106	17.56	4.19	35.12	43	3.25	0.88
138	164	31	5.44	1.25	76	13.44	2.94	107	18.88	4.19	37.76	81	5.88	2.81
139	170	16	3.56	0.75	85	15.00	3.44	101	18.56	4.19	37.12	67	5.25	1.50
140	180	13	2.50	0.50	112	18.06	4.13	125	20.56	4.63	41.12	62	4.38	1.19
141	128	18	3.69	0.75	101	14.50	2.88	119	18.19	3.63	36.38	53	3.50	1.00
142	38	22	4.25	0.88	120	18.81	4.19	142	23.06	5.06	46.12	62	4.00	1.13
143	178	26	5.38	1.19	76	12.44	2.81	102	17.81	4.00	35.62	69	5.25	1.56
144	169	32	6.50	1.31	67	11.50	2.50	99	18.00	3.81	36.00	50	3.25	0.88
145	168	30	6.19	1.25	85	13.06	2.81	115	19.25	4.06	38.50	55	3.69	1.13
146	139	34	6.94	1.31	96	15.81	3.44	130	22.75	4.75	45.50	88	6.63	1.94
147	129	38	8.44	2.06	64	11.13	2.69	102	19.56	4.75	39.12	73	6.44	2.00

TABLE 3—Concluded.

Row No.	Parent ear No.	A 1 Seed.			Good Seed.			Total Seed.			Bushels of seed per acre.	Nubbins.		
		No. of ears.	Weight of shelled corn in lbs.	Cob weight in lbs.	No. of ears.	Weight of shelled corn in lbs.	Cob weight in lbs.	No. of ears.	Weight of shelled corn in lbs.	Cob weight in lbs.		No. of ears.	Weight of shelled corn in lbs.	Cob weight in lbs.
148	144	44	9.44	2.00	81	12.69	2.75	125	22.13	4.75	44.26	81	5.63	1.69
149	9	24	5.13	2.00	119	21.19	4.50	143	26.31	6.50	52.62	37	2.38	0.63
150	174	15	3.13	0.69	110	15.25	3.75	125	18.38	4.44	36.76	91	5.19	1.81
151	35	13	2.75	0.56	91	15.44	3.69	104	18.19	4.25	36.38	54	3.56	1.38
152	125	16	2.88	0.63	78	12.81	3.13	94	15.69	3.75	31.38	67	4.00	1.38
153	64	26	5.63	1.19	83	14.19	3.19	109	19.81	4.38	39.62	33	2.31	0.75
154	59	13	2.56	0.56	87	15.44	3.50	100	18.00	4.06	36.00	41	2.81	0.87
155	58	24	5.00	1.13	69	12.63	3.00	93	17.63	4.13	35.26	38	2.88	0.88
156	147	2	0.88	0.06	106	17.44	3.88	108	18.31	3.94	36.62	49	3.19	1.00
157	62	30	6.13	1.38	71	11.50	2.56	101	17.63	3.94	35.26	52	3.69	1.19
158	137	21	5.44	1.06	88	14.88	3.31	109	20.31	4.38	40.62	42	3.44	1.00
159	176	23	5.31	1.13	58	11.63	2.63	81	16.94	3.75	33.88	54	4.25	1.38
160	134	15	3.13	0.63	89	15.88	3.25	104	19.00	3.88	38.00	55	4.06	1.13
161	51	10	2.13	0.38	97	16.56	3.50	107	18.69	3.88	37.38	48	3.31	1.00
162	167	16	3.75	0.69	76	13.38	2.88	92	17.13	3.56	34.26	36	3.00	0.75
163	160	24	4.44	1.00	80	12.56	3.00	104	17.00	4.00	34.00	51	4.06	1.25
164	177	28	5.94	1.25	45	7.69	1.63	73	13.63	2.88	27.26	32	2.44	0.63
165	1	14	2.88	0.63	54	10.00	2.25	68	12.88	2.88	25.77	54	3.94	1.19
166	5	29	5.25	1.25	46	7.25	1.75	75	12.50	3.00	25.00	21	1.38	0.44
167	29	28	5.69	1.25	52	7.63	1.56	80	13.31	2.81	26.62	33	3.94	0.69
168	33	16	3.50	0.75	76	12.88	2.75	92	16.38	3.50	32.76	31	2.50	0.69
169	8	26	5.06	1.00	72	11.56	2.50	98	16.63	3.50	33.26	49	2.94	0.88
170	194	16	3.56	0.69	62	9.50	2.25	78	13.06	2.94	26.12	37	2.69	0.81
171	223	8	1.63	0.31	92	15.38	3.38	100	17.00	3.69	34.00	32	2.50	0.75
172	68	19	3.94	0.88	72	11.81	2.44	91	15.75	3.31	31.50	22	1.75	0.50
173	17	14	2.56	0.50	85	13.69	3.06	99	16.25	3.56	32.50	40	2.88	0.88
174	6	23	4.31	0.81	70	12.75	2.56	93	17.06	3.38	34.12	44	2.81	0.88
175	45	11	2.00	0.38	60	8.63	1.75	71	10.63	2.13	21.26	46	3.13	0.88
176	60 B	15	3.06	0.56	75	12.75	2.56	90	15.81	3.13	31.62	60	4.69	1.13
177	132A	18	3.69	0.81	69	11.00	2.63	87	14.69	3.44	29.38	24	1.56	0.44
178	60 A	10	1.94	0.63	61	10.06	2.19	71	12.00	2.81	24.00	62	4.63	1.31
179	132 B	21	3.88	0.94	69	10.50	2.56	90	14.38	3.50	28.76	19	1.25	0.38
180	165	8	1.56	0.31	58	9.31	1.88	66	10.88	2 19	21.76	46	3.75	1.00
181	206	10	1.75	0.31	83	12.06	2.25	93	13.81	2.56	27.62	31	2.13	0.56
182	67	27	5.31	1 13	75	12.31	2.56	102	17.63	3.69	35.26	19	1.63	0.44
183	198	14	2.88	0.63	74	12.63	2.75	88	15.50	3.38	31.00	40	3.19	0.94
184	172	23	4.38	0.94	85	12.75	2.94	108	17.13	3.88	34.26	30	2.06	0.63
185	151	12	2.50	0.50	66	11.63	2.50	78	14.13	3.00	28.26	41	2.94	0.94
186	171	12	2.50	0.50	71	11.00	2.50	83	13.50	3.00	27.00	21	1.94	0.44
187	49	7	1.50	0.25	68	11.38	2.38	75	12.88	2.63	25.76	40	3.00	0.88
188	141	19	3.88	0.81	80	13.56	2.94	99	17.44	3.75	34.88	54	2.75	1.13
189	116	32	6.31	1.25	86	13.31	2.81	118	19.63	4.06	39.26	63	2.94	0.81
190	130	24	5.06	1.13	77	13.75	3.19	101	18.81	4.31	37.62	43	2.56	0.94
191	136	27	5.38	1.13	66	12.00	2.56	93	17.38	3.69	34.76	31	2.50	0.75
192	78	21	4.50	1.00	80	12.81	2.88	101	17.31	3.88	34.62	29	2.00	0.75
193	115	16	3.38	0.75	73	12.44	2.81	89	15.81	3.56	31.62	39	2.31	0.75
194	42	14	2.63	0.50	89	13.63	3.13	103	16.25	3.63	32.50	46	3.63	1.00
195	7	19	3.63	0.81	79	13.00	2.94	98	16.63	3.75	33.26	38	2.56	0.75
196	46	23	4.75	1.06	45	7.38	1.94	68	12.13	3.00	24.26	33	2.31	0.75
197	72	21	4.81	1.00	75	14.00	2.94	96	18.81	3.94	37.62	35	2.63	0.75
198	127	35	7.00	1.44	86	13.69	2.88	121	20.69	4.31	41.38	30	2.00	0.63
199	133	21	4.25	0.88	86	13.75	3.19	107	18.19	4.06	36.38	26	1.88	0.56
Averages.		21.09	4.35	0.92	80.18	13.30	2.96	101.27	17.65	3.88	35.29	45.86	3.17	0.99

TABLE 4.

Yield of Each Row of Type II Corn in 1908.

		A 1 Seed			Good Seed			Total Seed				Nubbins		
Row No.	Parent ear No.	No. of ears	Weight of shelled corn in lbs.	Cob weight in lbs.	No. of ears	Weight of shelled corn in lbs.	Cob weight in lbs.	No. of ears	Weight of shelled corn in lbs.	Cob weight in lbs.	Bushels per acre	No. of ears	Weight of shelled corn in lbs.	Cob weight in lbs.
202	375	34	7.25	1.69	81	15.13	3.56	115	22.38	5.25	29.54	32	2.81	0.75
203	88	50	10.69	2.81	82	15.13	3.88	132	25.82	6.69	34.08	46	3.19	1.00
204	84	45	10.19	2.63	69	14.56	3.56	114	24.75	6.19	32.67	27	2.25	0.69
210	387	39	8.13	1.88	69	12.88	3.13	108	21.00	5.00	27.72	15	1.31	0.38
214	333	27	5.94	1.50	96	18.38	4.06	123	24.31	5.56	32.09	33	2.69	0.81
218	357	30	6.44	1.50	81	15.31	3.81	111	21.75	5.31	28.71	20	1.69	0.50
221	106	31	6.06	1.63	111	21.06	5.50	142	27.12	7.13	35.80	29	2.13	0.69
224	361A	37	8.00	2.00	78	16.31	4.13	115	24.31	6.13	32.09	22	1.88	0.50
230	396A	50	10.63	2.94	60	12.25	3 13	110	22.88	6.06	30.20	24	2.25	0.69
231	105A	30	6.13	1.50	72	12.69	3.06	102	18.81	4.56	24.83	25	1.94	0.56
253	292	21	4.25	0.94	57	10.00	2.31	78	14.25	3.25	18.81	12	0.94	0.25
Averages		35.8	7.61	1.91	77.8	14.89	3.65	113.9	22.49	5.56	29.68	25.9	2.98	0.62

A number of interesting points come out of these tables. Among these are the following:

1. Taking the Type I corn first it appears that on the average over the whole plot 21 out of every 101 ears fit to be used for seed at all were of such superior quality as to be placed in the A1 class. This is a high ratio as compared with the seed which the packers ordinarily distribute to the farmer.

2. The same fact is brought out in a more striking way by considering the weight of shelled corn produced on the different classes of ears. On the average 24.6 per cent. by weight of the shelled corn of seed quality came from ears graded as A1.

3. As would be expected from the above relations there was only a small proportion of the total crop unfit for seed. Taking the average of all the rows only 15.2 per cent. of the total yield of shelled corn was borne on nubbins or poor ears which could not be classed as good seed.

4. The average yield in bushels per acre of dried and shelled seed corn for all rows was 35.29. Considering the fact that this is for a stand of only one stalk to a hill it can only be regarded as a very good yield. The distribution of the yields for each of the 100 rows is shown graphically in Fig. 223.

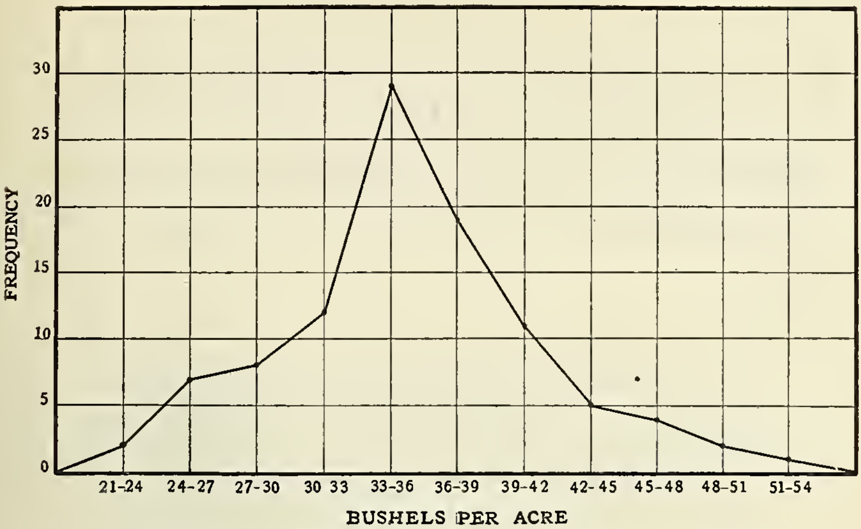

Fig. 223. Diagram showing the yield of the 100 rows of Type I corn in bushels per acre.

From this diagram it appears that the yield which occurred most often was in the class 33-36 bushels. From this high point the polygon slopes off at about the same angle in both directions—*i. e.*, towards higher as well as lower yields.

5. Even the 11 best rows of the Type II corn, selected because they were the best in the field, did not average to yield as well as the whole of the 100 rows of the Type I, good, bad and indifferent taken together. The Type II falls behind nearly 6 bushels to the acre.

6. Further, even in these 11 best rows the Type II corn did not produce nearly so high a proportion of its total shelled corn on ears of good quality which warranted their use for seed. Thus, taking averages of the 11 rows it appears that of the total yield 48.2 per cent. was borne on nubbins or ears not good enough to use for seed. This figure is to be compared with the 15.2 per cent. in the case of the Type I corn.

7. The shelling ratio is also slightly higher in the Type I averages for the whole field than in the case of the 11 selected rows of Type II. From Table 3 it appears that in the case of the "A1 seed" of Type I, 17.5 per cent. of the average weight of the ear was cob (shelling percentage=82.5), and in the "good seed" of the same type of corn, 18.9 per cent. of the average weight of the ear was cob (shelling percentage=81.1). On the other

hand, the Type II "A1 seed" has 19.1 per cent. of the total weight in cob, and the "good seed" has 19.6 per cent. in cob (shelling percentage 80.9 and 80.4 respectively). It should again be pointed out that a part at least of the poor showing of the Type II (Crosby) corn as compared with the Type I (Dennett) is to be explained as a result of the fact that the former was planted in the ear-to-row test in a locality to which it was not "adjusted," while the Type I was.

In addition to the collection of data regarding the rows as wholes, individual plant selections were made in 1908, just as in 1907, except that in this year the selections were made in the ear-to-row plots. The ears from these field selections were used in an ear-to-row test in 1909, with results to be described farther on in connection with the work of that year. Data were taken on these ears selected in 1908 similar to those already given for the 1907 ears.

The question of the relation of type, conformation and size of ear to yield and quality in the progeny is one of great importance to the corn breeder. While it is not possible in a general discussion, such as this is intended to be, to go deeply into this matter it is thought desirable to present some photographic material which we have collected bearing on the subject. These pictures have the further advantage of recording in some measure the progress made in the selection work, so far at least as certain ear characters are concerned. There will be presented some photographs of the ears selected in 1907 for planting in 1908, together with a brief discussion of their progeny in 1908. It should be said that in all cases where an ear shown in these photographs is crooked it became so in drying, and was not so originally. The corn was dried on racks so constructed that each ear was thrust, at the butt end, on a nail projecting from the rack. The weight of the ear itself caused some to curve in the process of drying.

Figures 224 and 225 show two groups of ears selected in 1907, one of which produced relatively high yielding rows, and the other relatively low yielding rows.

It is instructive to compare individual ears. Ear No. 113 (Fig. 224) while bearing almost identically the same amount of shelled corn as ear No. 1 (Fig. 225) (80.90 gr., as against 80.10 gr.) produced a row yielding at the rate of 48.00 bushels

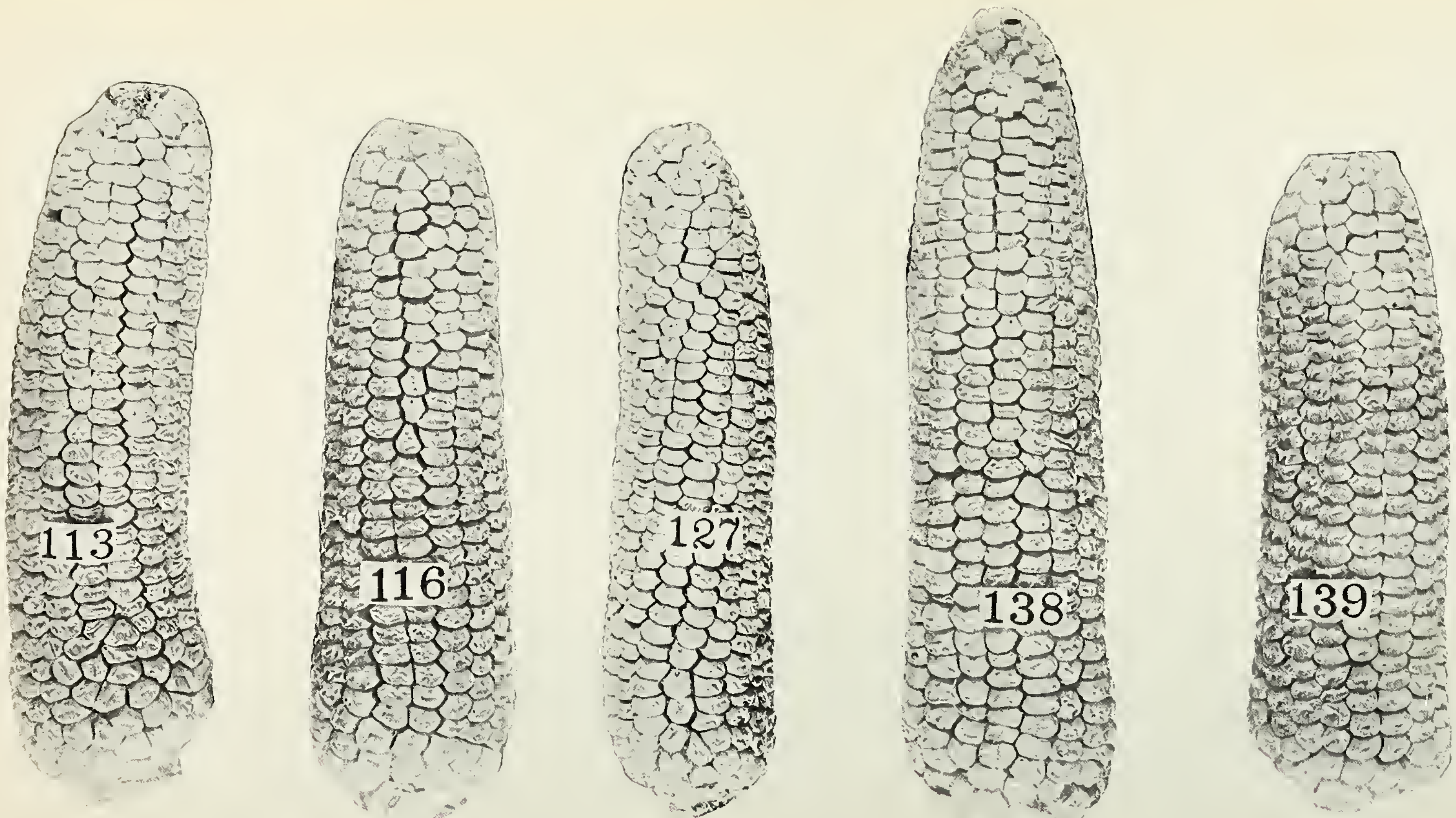

FIG. 224. Photographs of sweet corn ears selected in 1907. Produced relatively *high* yielding rows in 1908

FIG. 225. Photographs of sweet corn ears selected in 1907. Produced relatively *low* yielding rows in 1908.

to the acre, while ear No. 1 produced a row yielding but 25.77 bushels to the acre. Ear No. 1 had but 76.22 per cent. of its total yield on ears good enough for seed, while ear No. 113 has 93.42 per cent. of its total yield on such ears.

Again ear No. 113 may be compared with No. 116. The latter was certainly the better looking ear, yet it yielded at the rate of 10 bushels to the acre less than No. 113.

Ear No. 127 (Fig. 224), which was a smaller ear (66.50 grams shelled corn) than any ear in Fig. 225 with the exception of ear No. 60, yielded at the rate of 41.38 bushels to the acre as against 29.38 bushels to the acre, the highest yield of any of the ears shown in Fig. 225, that of ear No. 132.

Ear No. 127 (Fig. 224) produced a row yielding at the rate of 1.38 bushels per acre higher than the row produced by ear No. 138 (Fig. 224), which was relatively a giant beside it.

Ear No. 139 (Fig. 224) produced one of the highest yielding rows in the test, giving 45.50 bushels to the acre, yet this ear had the smallest net weight of shelled corn (61.90 grams) of any of the 5 ears shown in Fig. 224. Ear No. 29 (Fig. 225) was one of the heaviest ears selected (bearing 88.10 gr. shelled corn) yet it produced a row yielding at the rate of but 26.62 bushels to the acre.

These facts are very striking. They indicate that there is not that close association between the size and type of the ear and the resulting yield, which many would have us believe. The proper method of studying this matter is, of course, to measure mathematically the correlation between ear characters and yield. This is being done in this laboratory, but a technical discussion of the results is not in order here. These photographs show clearly enough that such an association of characters and yield cannot be very close or definite. This is a result in accordance with some data recently published by Williams and Welton of the Ohio Station.*

The point may be raised that in Figs. 224 and 225 we are dealing with extremes in the positive and negative directions. What would be the type and size of ears producing good average yielding rows? Such rows would in our 1908 experiment be represented by yields of from 33 to 36 or 37 bushels. In figures 226 and 227 data are given for an examination of this question.

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* Williams, C. G., and Welton, F. A. Ohio Agric. Exp. Sta. Bulletin 212, 1909.

The difference in appearance of the ears in these two figures is striking indeed. The ears in Fig. 227 are poor scrubby looking things, which anybody selecting seed for anything but an experiment would surely reject. On the other hand, the ears in Fig. 226 are of fine quality. Every one is of the cylindrical type so much sought after in corn, and each has a beautifully rounded tip evenly covered with grain. Each one of the ears shown in these two pictures was planted, *and each one produced a row yielding within 2 bushels (above or below) of the average of the whole plot.* The average rate of yield of the rows from the 5 ears of Fig. 226 was 36.10 bushels per acre, while that for the 5 ears in Fig. 227 was 35.00, or, in other words, *the average rate of yield per acre was only 1.1 bushels more for the rows from the ears of Fig. 226 than for those from the ears of Fig. 227.*

Another question which suggests itself is as to the quality of the ears in the rows produced from the ears shown in Figs. 226 and 227. Was it not the case that while the net weight of shelled corn was substantially the same for the two sets of rows from these different ears yet the proportion of this borne on nubbins and ears of too poor quality for seed was higher in the rows from the poor ears of Fig. 227 than from the good ears of Fig. 226. One would suppose this surely to be the case. Ears like 172 (Fig. 227) have been set forth to the readers of agricultural literature as glaring and shocking examples of what not to plant. Now as a matter of fact, out of the total amount of shelled corn produced by the progeny of these two set of ears, an average of 13.67 per cent. was produced on nubbins and ears too poor for seed in the case of the progeny of the ears of Fig. 226, against an average of 13.58 per cent. in the case of the progeny of the ears of Fig. 227. Or, in other words, *the progeny of the good ears of Fig. 220 produced just as much (and indeed an insignificant trifle more) corn on nubbins and ears too poor for seed as did the progeny of the poor ears of Fig. 227.*

Turning now to the other side of the case let us ask what was the proportion of high quality ears (A1 seed) produced by the progeny of the two sets of ears shown in Figs. 226 and 227. We may again take the total weight of shelled corn as the base of comparison. The progeny of the poor ears of Fig. 227, tak-

FIG. 226. Sweet corn ears selected in 1907 for planting in 1908. These are ears of *good* type producing good average yielding rows.

FIG. 227. Sweet corn ears selected in 1907 for planting in 1908. These ears are of *poor* type producing good average yielding rows.

ing the average for the 5, produced 20.68 per cent. of their total shelled corn on ears of A1 quality, while the progeny of the good ears of Fig. 226 produced 20.40 per cent. of their total shelled corn on such ears. *In other words, the progeny of the ears of Fig. 226 included on the average no more ears of fine quality than did the progeny of the ears of Fig. 227.*

How are such results as these to be interpreted? It is, of course, open to one to maintain if he chooses that the cases illustrated are merely isolated instances—exceptions which prove the rule as it were. As a matter of fact these cases are not exceptions. They agree essentially with the great bulk of data regarding inheritance accumulated by the experimental work of recent years in supporting the generalization that the external, visible characteristics of a plant or animal furnish an exceedingly unreliable criterion of its probable behavior in breeding. The fact that an ear of corn is of especially good type and appearance is no guarantee that its progeny will also be better than the average. These corn ears illustrate exactly the same principles that have been brought out in the studies on breeding for egg production at this Station.* The force of such facts as are here set forth and the general principles upon which they depend, is making itself felt in practical corn breeding work in the western states. The writers gather from their reading of such papers as the Breeders Gazette (and they are informed by competent authority that their conclusion on this point is quite correct) that among the most careful and thoughtful of the corn belt farmers and breeders of seed corn there is developing a marked reaction from the belief in the great value of the "show" type of ears for seed raising purposes. It is being found by corn breeders everywhere that such ears do not always or even in the majority of cases produce the highest yields or the largest proportion of perfect ears.

Facts of the character brought out by these protographs of corn ears are capable of satisfactory interpretation on the basis of Johannsen's ** concept of genotypes. According to this view the ears shown in Fig. 227 represent very poor individual speci-

* Cf. Me. Agr. Expt. Stat. Bulletin 166 and Bureau of Animal Ind. Bulletin 110, Part I.

** Cf. this author's recent book "Elemente der exakten Erblichkeitslehre." Jena (Fischer), 1909.

mens belonging to mediocre genotypes, whereas the ears in Fig. 226 represent very good individual specimens but also from mediocre genotypes. If both sets belong to genotypes of about the same general grade or character it is to be expected that the progeny of both sets of ears will be essentially the same. This as a matter of fact was the case. The genotype concept gives at once a more reasonable interpretation of the facts than is to be gained from any other current view of the nature of the process of inheritance, and suggests the factors of primary importance to be looked after in practical corn breeding. Evidently if the genotype idea represents the actual method of inheritance in corn, the important test in selecting seed is the performance of the progeny. The aim must be to propagate the strains or lines in which high yield, fine quality of ears, etc., are *hereditarily* present. At the same time one must, of course, guard against any loss of vigor by too much or too close inbreeding.* It is obvious that in an open fertilized plant like corn one will never (except by hand pollination) get pure lines such as Johannsen has studied in beans. But to suppose, as some writers have apparently done that, because of this fact, the genotype concept has no significance for sexually reproducing animals and open fertilized plants, is merely a confession of a lack of understanding of the fundamental meaning of that concept.

Work in 1909—I. Ear-to-Row Test.

The ear-to-row test of the ears from individual plant selection was carried out on the farm of Mr. J. H. Heath at Farmington again in 1909. Land was taken for the work on the "intervale" contiguous to that used in Plot I in 1908. The soil was of the same character. In addition to the ear-to-row test a number of other test plots were carried on in 1909. Besides the experimental plots Mr. Heath grew two acres of corn for himself from seed selected for him by the writers. This corn was on the same "intervale" land immediately west of the experimental plots This gave nearly 3 acres of the Type I pedigreed sweet corn grown in the same field at Farmington under direct observation, and in the local conditions to which it was thoroughly adjusted.

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* This point has been much discussed in recent writings on corn breeding problems, especially by Shull, East, Cook, Spillman, and Collins.

The season of 1909 was an extremely unfavorable one for corn. Following a cold and wet spring the early part of the summer was characterized by a long succession of cloudy, cold days. The result was that sweet corn throughout the State got a very bad start. The relative amount of growth made in July was much below the normal for a favorable season. This, coupled with the fact that the late spring delayed the planting, made the sweet corn through the State in general mature late. To make the season about as unsatisfactory as possible from the corn grower's standpoint killing frosts came early in the fall and severely damaged the crop. These seasonal conditions must be kept in mind throughout the following discussion.

The data regarding the planting of the ear-to-row test plot in 1909 are as follows: The plot, as has been said, was located on the "intervale" as in 1908. Only Type I corn was used in the planting. One ear was planted to a row as before. The plot was smaller and the rows shorter than in 1908. The rows were 3 feet apart and the hills 18 inches. The plot measured 148 feet x 75 feet, 49 rows being planted. The land used was in grass in 1908. It was given a good coat of manure, plowed in the spring of 1909 and in general given the same treatment as described for the 1908 ear-to-row test. Bradley's Corn Phosphate was applied at the rate of 900 lbs. to the acre. This was put in the hills in the way described for the 1908 work. The plot was planted May 20, 1909. In this year's work the thinning was done so as to leave 2 stalks to the hill rather than one as in 1908. The cultivation was otherwise as in 1908.

The data regarding the ears planted in the ear-to-row test in 1909 are given in Table 5. There is also included in the last 2 columns of this table a statement of the yield of each row.

TABLE 5.

Data on Type I Corn Ears Planted in Ear-to-Row Test in 1909, and the Yield of the Resulting Rows.

Ear No.	Parent Ear No.	Weight.	Rows.	Kernels to row.	Butt circumference in cms.	Tip circumference in cms.	Cob butt circumference in cms.	Cob tip circumference in cms.	Cob weight in gms.	Length in cms.	Net weight shelled corn in gms.	Germination.	Planted row No.	Yield. Pounds shelled corn.	Yield. Bushels per acre.
401	193	109.0	18	36	13.5	9.5	8.8	6.0	20.0	15.3	89.0	100	501	7.94	39.05
403	40	72.0	20	32	13.1	11.5	9.0	6.8	17.0	14.4	55.0	96	503	9.19	45.20
412	64	94.0	16	36	13.3	10.6	8.7	6.6	20.0	17.4	74.0	96	507	10.63	52.28
417	138	140.0	18	37	13.9	10.3	8.3	5.1	23.0	18.8	117.0	96	515	11.31	55.62
421	173	135.0	20	41	13.8	12.1	8.5	5.5	22.0	17.5	113.0	100	529	10.75	52.87
433	222	133.0	16	36	14.8	10.5	10.4	5.7	26.0	15.7	107.0	100	522	10.50	51.64
439	34	141.0	16	38	13.6	10.0	9.0	6.5	25.0	18.8	116.0	92	528	10.44	51.34
442	36	140.0	20	33	14.3	9.8	9.5	6.2	26.5	16.5	113.5	100	516	10.06	49.48
445	199	72.5	16	30	12.4	10.5	8.0	6.5	11.0	13.0	61.5	100	511	8.94	43.97
446	193	99.0	22	31	15.0	11.5	10.8	7.0	21.5	14.6	77.5	100	506	9.75	47.95
448	193	128.0	18	35	13.8	11.7	8.8	6.3	22.0	16.5	106.0	92	532	8.69	42.74
454	6	103.5	18	35	13.3	10.9	7.9	6.4	18.5	16.3	85.0	100	548	7.00	34.43
455	113	73.5	20	24	13.9	12.8	9.5	7.7	15.5	11.4	58.0	100	538	9.38	46.13
457	113	157.0	16	42	14.6	11.0	10.0	6.5	30.5	19.2	126.5	96	514	9.88	48.59
461	138	90.0	18	33	13.8	11.4	9.0	6.3	18.0	13.9	72.0	100	508	10.88	53.51
465	162	122.0	16	39	13.8	11.0	9.0	6.6	24.5	15.8	97.5	100	535	11.44	56.26
485	204	73.5	16	36	12.6	10.6	8.3	5.9	15.5	15.7	58.0	100	512	11.06	54 39
*493	193	48.0	?	22	10.8	9.4	7.0	6.6	10.5	14.3	37.5	96	546	7.50	36.89
*499	168	78.5	14 ?	31	12.2	8.8	8.3	6.6	16.0	14.0	62.5	100	547	9.50	46.72
501	139	77.0	16	28	12.8	9.9	8.5	5.5	15.5	15.5	61.5	96	510	10.50	51.64
502	168	85.0	18	33	13.2	10.1	8.0	5.7	14.0	14.0	71.0	100	509	12.13	59.66
508	64	90.0	16	38	13.5	9.7	9.0	6.0	22.0	17.0	68.0	96	540	10.88	53.51
510	64	94.0	14	35	13.5	10.0	8.8	5.9	20.5	18.2	73.5	96	513	10.50	51.64
513	137	132.0	20	37	14.9	11.5	10.0	6.2	27.5	17.2	104.5	100	523	11.88	58.43
527	127	104.0	20	34	13.2	10.3	9.3	6.1	22.5	18.5	81.5	100	504	9.50	46.72
544	137	98.0	20	36	13.8	11.1	9.3	8.8	19.5	14.8	78.5	100	505	10.25	50.41
548	40	103.0	18	36	15.0	11.5	9.9	6.2	20.5	15.0	82.5	100	502	8.63	42.44
550	29	92.0	18	31	12.9	10.5	7.8	5.8	17.0	14.8	75.0	88	545	10.75	52.87
555	45	84.0	16	30	12.5	9.8	7.6	5.5	16.5	12.5	67.5	100	543	10.00	49.18
559	171	96.5	20	31	14.2	11.9	9.3	7.2	18.5	14.0	78.0	100	542	8.94	43.97
562	164	68.0	20	24	12.9	10.7	8.7	7.2	12.5	13.0	55.5	96	539	10.56	51.93
564	49	62.0	18	30	12.9	10.6	9.0	6.5	12.5	12.5	49.5	100	544	8.75	43.03
574	50	129.5	16	39	14.1	10.4	9.8	6.5	25.5	17.2	104.0	96	531	9.31	45.79
576	50	125.5	18	37	14.2	12.3	10.0	7.8	25.5	17.2	100.0	96	534	8.88	43.67
577	50	139.0	20	39	15.5	12.7	12.0	7.5	24.0	14.4	115.0	96	524	8.88	43.67
578	22	123.5	16	36	14.5	12.2	9.9	7.2	23.5	15.0	100.0	100	533	10.00	49.18
584	199	128.0	18	41	14.1	10.5	8.2	5.5	19.5	16.6	108.5	100	520	10.75	52.87
586	164	155.5	20	41	15.5	11.5	10.5	6.8	29.5	17.2	126.0	100	525	8.13	39.98
589	139	138.5	18	43	14.7	12.0	9.4	7.3	25.0	16.6	113.5	100	517	10.25	50.41
592	129	131.5	18	39	14.9	12.2	9.5	7.2	28.5	17.0	103.0	88	521	11.56	56.85
596	9	118.0	16	33	14.3	11.5	9.3	6.5	21.0	14.8	97.0	100	537	10.44	51.34
597	9	129.5	16	39	14.2	12.0	9.5	6.5	21.0	15.7	108.5	96	549	8.63	42.44
598	9	133.0	16	36	14.5	11.4	9.5	6.4	22.0	15.0	111.0	92	518	10.69	52.57
600	137	134.0	16	36	14.9	12.0	9.8	6.9	25.0	14.8	109.0	96	536	12.00	59.02
602	1	141.5	18	40	14.9	11.0	10.3	6.5	31.0	16.5	110.5	100	541	7.00	34.43
604	194	147.0	20	38	15.7	11.8	11.0	6.9	25.5	16.7	121.5	100	527	10.06	49.48
608	172	124.0	20	37	14.2	11.3	9.5	6.4	19.5	15.3	104.5	96	530	9.19	45.20
609	115	132.0	20	35	11.9	12.4	9.9	7.7	22.0	15.1	110.0	100	526	8.50	41.80
720	24	137.0	16	39	14.6	11.3	10.0	6.7	26.0	17.0	111.0	96	519	10.13	49.82
Means..		113.52	17.9	35.4	13.9	11.1	9.3	6.5	21.48	15.7	92.04	97.7	-	9.90	48.71

* These two ears were hand pollinated, and in consequence were not well filled. The data from these two ears are omitted from the averages given below.

By comparison of Table 1 (p. 259) (ears selected in 1907) and Table 5 (ears selected in 1908) a number of interesting points are brought out. It appears that, on the average, the ears selected as seed for 1909 planting were of higher quality in respect to practically all characters than the ears selected for planting in 1908. Thus the average weight of ear was about 18 grams more in the 1908 selections than in the 1907. There was an increase of nearly one-half row in the average number of rows in the 1908 selection as compared with 1907. The 1908 seed ears were on the average longer by about a half centimeter, had more kernels to the row, and a relatively smaller cob than the 1907 ears. In mean net weight of shelled corn to the ear the 1908 selections were about 17 grams higher.

In regard to quality in general, including shape of ear, filling of butt and tip, straightness of rows, fineness of grain, etc., the 1908 selections were as a whole, a very fine lot of ears. This is indicated by the illustrations of typical ears given in the plates farther on in the bulletin.

The yields of the rows in 1909 were in general at a higher rate than in 1908. The major portion, if not all, of this difference is due to the difference in the stand in the two years; one stalk to a hill in 1908, 2 in 1909.

There were two clear cut and striking general results of the test in 1909. The first of these was that the corn was again extremely early as compared with other sweet corn. It is very doubtful if any *gain* over the condition in regard to this character in 1908 was made. If it was it certainly could only have been slight in amount. But in any event all that was gained in 1908 was retained in 1909, making due allowance for differences in the two seasons. The following dates show the development of the corn in 1909. As has been said, it was planted May 20, 1909.

On June 19, 1909, the corn was found to be in good condition with fine even stand, no hills missing. Plants were from 12 to 18 inches high. On June 29, 1909, about one-third of the plants showed tassels starting. July 12, 1909, the field was well out in tassel. July 22 to 25 the silk was well out over the whole field. According to Mr. Arthur Tucker, superintendent of the Burnham and Morrill factory at Farmington, the entire three acres of corn was in the proper stage for canning on August

20-24, 1909. On August 29, 1909, Mr. Heath and one of the writers went through his two acres of corn in the attempt to find some ears suitable for boiling. After considerable searching a few ears were found but even these were already past the proper stage for eating. Owing to the location of the field on the low land along the Sandy river this corn was not injured by the severe frost of August 31, 1909. The corn was harvested for seed on September 15 and 16, 1909. It was thoroughly ripe at that time.

In connection with the farm distribution test (cf. pp. 284-292) of the Type I seed in 1909 the writers had an opportunity to see a great deal of the sweet corn grown in the State in that season. No corn was found which was as early as our piece at Farmington. Only a few pieces were seen which approached our corn in earliness. The best of these were in the vicinity of Rumford Center. This corn was about a week later than the Farmington field. On inquiry into the history of this corn it was found that the seed had been saved and selected for earliness for many years by Messrs. J. H. and F. D. Martin of Rumford Point. Further, during this time they had grown this corn on the same farm and under the same conditions so that it was completely adjusted to its immediate local environment.

Some idea of the earliness of the Farmington corn in 1909 as compared with other corn in the State may be gained from the statement that so far as the writers have been able to ascertain no corn was canned in the State before September 10. 1909. It seems safe to say that our corn was at least two weeks earlier than the earliest corn put up by the packers. It is worth pointing out that if all the corn in the State could have been as far along as the Farmington field it would have been safely out of the way before the killing frost of August 31. 1909 This frost did thousands of dollars worth of damage to the corn crop of the State.

The second point in which an improvement concurrent with the selection was noticeable in the 1909 corn was in regard to the conformation of the ear. Unfortunately it was not possible under the conditions of the work to take detailed data on this point in 1909. but there is no doubt that the proportion of good and fine quality seed ears was considerably higher in 1909 than in

1908. This may be taken to indicate the results of the first step in the process of weeding out undesirable lines (genotypes) in regard to ear characters.

The superior quality of the seed ears planted in 1909 over those in 1908 is brought out by the photographs of typical ears shown in Figs. 228-230, especially by comparison with Figs. 224-227.

In Fig. 228 the ears are so arranged on the plate that the rate of yield of the progeny of each ear in bushels per acre increases as we pass from the ear on the extreme left (No. 602) to the ear on the extreme right (No. 600). The first three ears at the left (Nos. 602, 586 and 609) gave rise to rows which yielded poorly. The other two ears (Nos. 592 and 600) produced high yielding rows. The data regarding each of the ears in Fig. 228, and their progeny are given in Table 6.

TABLE 6.

Data Regarding the Progeny of the Ears Shown in Figure 228.

Ear No.	Weight of shelled corn in grams.	Planted row No.	Bushels per acre.	Parent row No.	Bushels per acre of parent row.	Parent Ear No.
602	110.5	541	34.43	165	25.77	1
586	126.0	525	39.98	138	37.76	164
609	110.0	526	41.80	193	31.62	115
592	103.0	521	56.85	147	39.12	129
600	109.0	536	59.02	158	40.62	137

Similar data for the ears of Fig. 229 are given in Table 7, and for those of Fig. 230 in Table 8.

TABLE 7.

Data Regarding the Progeny of the Ears Shown in Figure 229.

Ear No.	Weight of shelled corn in grams	Planted row No.	Bushels per acre	Parent row No.	Bushels per acre of parent row	Parent ear No.
448	106.0	532	42.74	131	37.76	193
574	104.0	531	45.79	113	37.38	50
576	100.0	534	43.67	113	37.38	50
577	115.0	524	43.67	113	37.38	50
578	110.0	533	49.18	117	33.50	22

TABLE 8.

Data Regarding the Progeny of the Ears Shown in Figure 230.

Ear No.	Weight of shelled corn in grams	Planted row No.	Bushels per acre	Parent row No.	Bushels per acre of parent row.	Parent ear No.
417	117.0	515	55.62	103	40.00	138
589	113.5	517	50.41	146	45.50	139
596	97.0	537	51.34	149	52.62	149
597	108.5	549	42.44	149	52.62	149
598	111.0	518	52.57	149	52.62	149

Figure 229 shows 5 ears which produced rows yielding a little below the average for the whole test. It is to be contrasted with Fig. 230 which gives 5 ears producing rows above the average (with one exception introduced for another purpose). The pictures show clearly enough that there is certainly no marked difference in the average quality of these two sets of ears, as they would be judged by a person picking out ears from a miscellaneous lot for planting. Yet the average rate of yield per acre of the progeny of the 5 ears of Fig. 230 is 5.47 bushels more than that of the progeny of the 5 ears of Fig. 229. In other words, the ears of Fig. 230 yielded approximately 10 per cent. better than those of Fig. 229. There certainly is not a 10 per cent. difference in the quality of the ears themselves, as shown in the photographs.

Each of these figures brings out some further special points of interest. Thus in Fig. 229 the three ears No. 574, 576 and 577 are all daughter ears from ear No. 50 shown in Fig. 226. Ear No. 50 was the best individual of all those selected in 1907. Two of the three grand-daughter rows (534 and 524) yielded at exactly the same rate. The ear shown beside No. 50 in Fig. 226 is No. 193, an ear of good shape but very short and small as compared with No. 50. Now ear No. 448 in Fig 229 is a daughter ear from No. 193. Neither in size, shape nor quality is it noticeably inferior to the daughter ears from No. 50 (574, 576 and 577). Furthermore the grand-daughter row from ear No. 193 yielded at substantially the same rate as did the grand-daughter rows from ear No. 50. In other words, it appears that ear No. 193 was just as good an ear for planting purposes as was ear No. 50, though no one would ever have supposed so on seeing the two ears side by side.

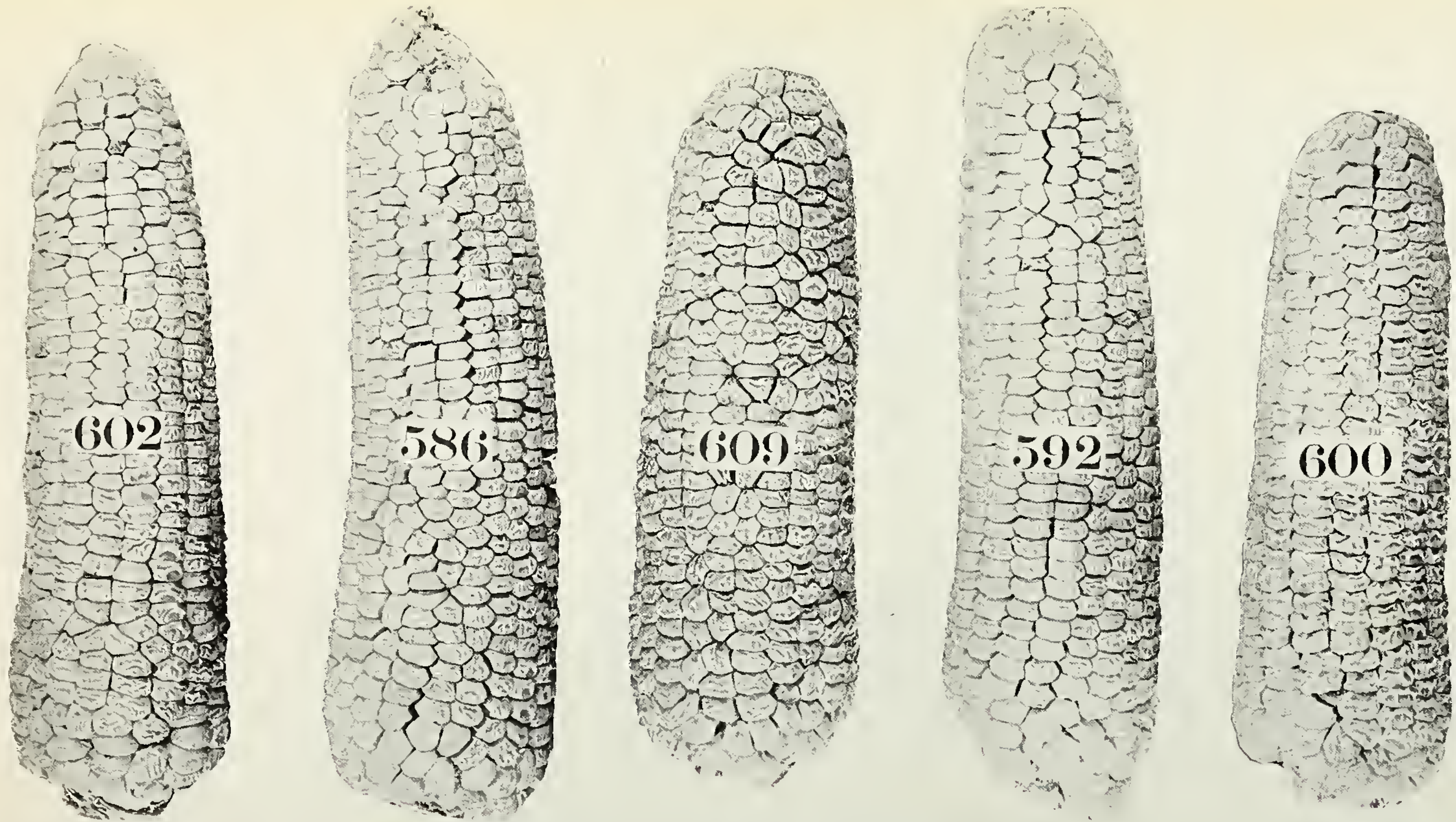

FIG. 228. Sweet corn ears selected in 1908 for planting in 1909.

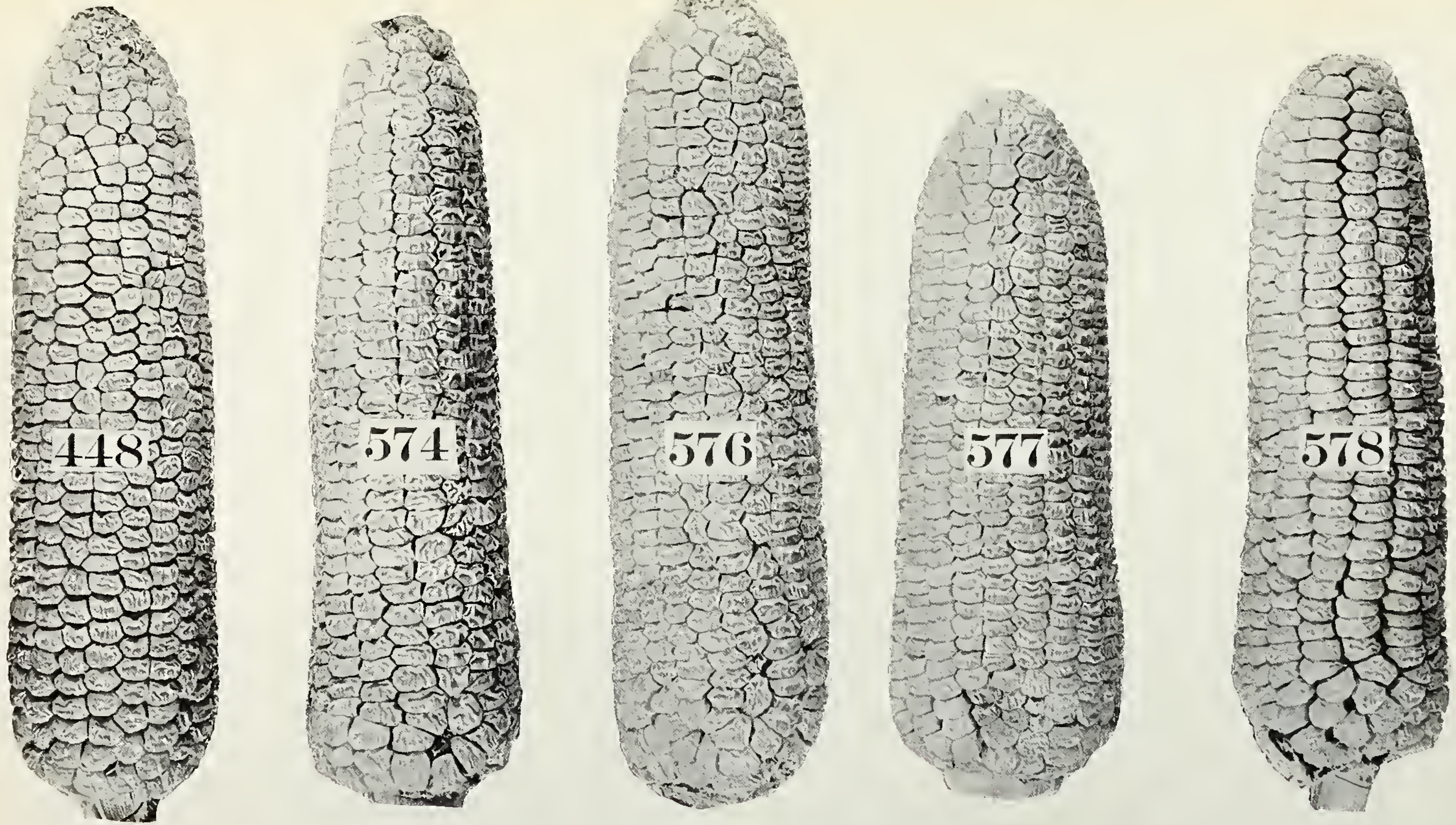

Fig. 229. Sweet corn ears selected in 1908 for planting in 1909.

Fig. 230. Sweet corn ears selected in 1908 for planting in 1909.

The same thing is brought out in a still more striking way so far as yield is concerned by comparing ear No. 578 with the 3 daughter ears from No. 50. Ear No. 578 is a daughter ear from the very poorly shaped, scrubby ear No. 22 shown in Fig. 227. Now while 578 is lacking in some particulars the high quality of Nos. 574, 576 and 577 yet after all it is a very good ear—far better than No. 22. But if we turn to the rate of yield of shelled corn to the acre it appears that the row from ear No. 578 (the grand-daughter row from ear No. 22) yielded nearly 10 per cent. better than any grand-daughter row from ear No. 50. In other words, suppose a farmer had been selecting ears for seed; the facts show that the outcome, so far as concerns the number of pounds of corn to be hauled to the factory, would have been better if ear No. 22 had been used to found a strain of seed rather than ear No. 50. Yet no one would ever think of using such an ear as No. 22 for planting if he could get anything better.

Such results as are here being discussed should not under any circumstances be taken to mean that the right thing to do when selecting seed is to pick out ears like No. 22, rather than those like No. 50. What the results do mean is that the external qualities of the ear, whether good or bad, are a very poor indication what that ear will do when planted We have here simply another illustration of the old adage to the effect that it is not possible to tell how far a frog can jump by mere inspection of the frog. His jumping capacity is determined by innate, invisible qualities and characters, only to be tested by making him actually jump. In precisely the same way it is not possible to tell by the appearance of the ear how well relatively it is going to yield when planted. Because, just as with the frog, the yielding capacity depends on innate, invisible qualities. The only way to tell how it will yield is to plant it and see. If it then does yield well it *was* a good ear, even though it may not have looked the part.

All this means practically that in selecting corn for seed *the selection must be on the basis of the performance of the progeny (here the row) as distinct from individual ear selection.* The best ears to select for seed are those which came from good *rows.* A poor ear from a good row is vastly better than good ears from a poor row when the planting is on the ear-to-row

system. The average condition of a row (on the ear-to-row system of planting) is in some degree an index of the genotypic condition of the parent ear. Or, in other words, it is an indication of what it is worth as a breeder or propagator, as distinguished from what it is worth merely as an ear.

All this has its bearing on the current tendency to exploit fancy seed *ears* as such, of which we are seeing so much. The man who pays $250.00 for a single ear of seed corn (which by hypothesis he himself did not raise on some kind of a pedigree system) has a most extraordinary degree of faith in his ability to tell by the appearance of the ear what it will produce. He would do well to read and ponder over Mark Twain's tale of the jumping frog. It has a moral for every breeder, whether of plants or animals.

II. Farm Distribution Test.

In addition to the ear-to-row test in 1909 there was also carried on an extensive trial of this corn on a practical scale. This was done through a distribution of the seed to a number of farmers located in different parts of the corn growing sections of the State. As has already been noted, it was found that the Type I corn grown in the 1908 ear-to-row test was very early, as well as of fine quality. The question at once raised itself as to whether this marked earliness was anything fixed or inherent in the selected strains, or was merely the result of the favorable conditions of soil and cultivtion under which it was grown, combined with a high degree of adaptation or adjustment of the seed to those conditions. While on the Darwinian or "gradual accumulation" theory of selection it would be absurd to suppose that selection for one generation alone would bring about and fix such a marked improvement in earliness as was noted in the 1908 work, the "isolation" or "genotypic" concept of the action of selection would lead to no such difficulty. That is to say, on this latter interpretation a permanent (i. e., definitely fixed) improvement as great as that actually observed is a quite possible result of a single generation of selection. But, as a matter of fact, was the improvement in earliness obtained actually fixed? It is obviously impossible to answer this question definitely by continuing to grow the corn on the same experimental plots at Farmington. Because if (as was

the actual case) the improvement in earliness *is* retained there in successive generations it is quite impossible to be certain whether this is because it is inherited or because the corn is quite perfectly adjusted to the local conditions. In all breeding work with corn certainly, and probably with many, if not all, other crops as well, these two factors must be very carefully distinguished, or incorrect conclusions are almost certain to be drawn.

It, therefore, seemed desirable to test on a large scale what this selected seed would do under a wide variety of environmental conditions. By cooperation with the packers mentioned above (p. 255) a farm distribution test was made in 1909. Through their aid it was possible to get from one-half to 2 acres of corn from this seed grown by each of 47 farmers. The name and address of each of these farmers together with the acreage grown are given in Table 9.

It should be said that the acreages given in this table are not estimates, but were determined by actual accurate measurement of the plots. Taking all the cooperating planters together the average acreage in the test per planter was 0.95 acre, an insignificant fraction under one acre. The largest number (21) planted between 1 and 1½ acres. The next largest number (17) planted from ½ acre to 1 acre. Only 6 out of the 47 planted less than ½ acre, and only 3 more than 1½ acres. Of the latter only one (Mr. Heath) planted more than 2 acres.

The largest number of growers in any single county was in Oxford (15). Cumberland and Androscoggin counties each had 6; Franklin and Kennebec each 5; Penobscot 3; York, Somerset and Waldo each 2; and Knox 1. This distribution fairly well covered the corn growing region of the State (cf. fig. 231), and included a wide range of environmental conditions.

TABLE 9.

List of Farmers Cooperating in 1909 Farm Distribution Test.

NAME.	TOWN	COUNTY.	ACRES
A. H. Adams	Canton Point	Oxford	0.32
Josiah G. Adams	Wilton	Franklin	1.21
H. W. Allen	Strong	Franklin	1.54
E. U. Archibald	West Poland	Androscoggin	1.46
Audrew G. Arey	Cumberland	Cumberland	0.89
Frank P. Attwood	West Minot	Androscoggin	1.05
P. S. Bradeen	East Sumner	Oxford	0.96
Geo. B. Bradford	Turner Center	Androscoggin	0.85
R. O. Briggs	Buckfield	Oxford	1.01
William Briggs	Livermore Falls	Androscoggin	0.80
Chas A. Buck	Buckfield	Oxford	1.05
E. H. Burkett	Union	Knox	1.41
Fred H. Chandler	New Gloucester	Cumberland	0.91
H. M. Clements	Brooks	Waldo	0.99
A. D. Cummings	South Paris	Oxford	0.98
J. L. Damon	Buckfield	Oxford	1.00
J. A. Doughty	Oxford	Oxford	1.00
E. H. Eastman	West Buxton	York	1.01
E. W. Eaton	Dexter	Penobscot	1.45
Henry French*	Rumford Center	Oxford	0.22
J. F. Fuller & Sou	South Paris	Oxford	1.01
H. M. Gage	Detroit	Somerset	1.08
J. H. Heath	Farmington	Franklin	2.02
W. A. Holt	Bethel	Oxford	0.97
J. W. Hunting	Welchville	Oxford	0.88
Geo. R. Kimball	North Bridgton	Cumberland	0.78
Edgar M. Lenfest	Manchester	Kennebec	1.39
J. H. and F. D. Martiu*	Rumford Center	Oxford	0.10
M. W. Merrill	Lisbon Falls	Androscoggin	0.84
O. F. Merrill	Gardiner	Kennebec	1.16
Ephriam Moore	East Newport	Penobscot	0.61
H. J. Mosher	New Vineyard	Franklin	1.02
F. W. Osborn	Farmington	Franklin	0.19
Herbert Penley*	Rumford Center	Oxford	0.38
Frauklin Pierce	Hebron	Oxford	0.96
H. J. Pullen	Dexter	Penobscot	1.14
Oren W. Ripley	South Montville	Waldo	1.11
Geo. Roberts	Harrison	Cumberland	1.09
F. L. Russell	Kents Hill	Kennebec	0.81
H. S. Talbot	Freeport	Cumberland	1.68
W. J. Thompson	South China	Kennebec	1.03
Granville Thurstou*	Rumford Center	Oxford	0.31
T. D. Salley & Son	Madison	Somerset	0.83
C. E. Scammon	West Buxton	York	0.56
Dexter D. Storer	Readfield	Kennebec	1.08
Herbert N. Waltou	North Leeds	Androscoggin	1.18
John R. Ward	New Gloucester	Cumberland	0.76
		Total	44.77

*These four fields were plauted from the same lot of seed.

To each of the persons mentioned in the above table we wish to express our thanks for the aid which they rendered in carrying out this farm distribution test.

The geographical distribution of the corn growers in this test is shown graphically in Fig. 231 which gives (as solid dots) the location of each grower on an outline map of the State.

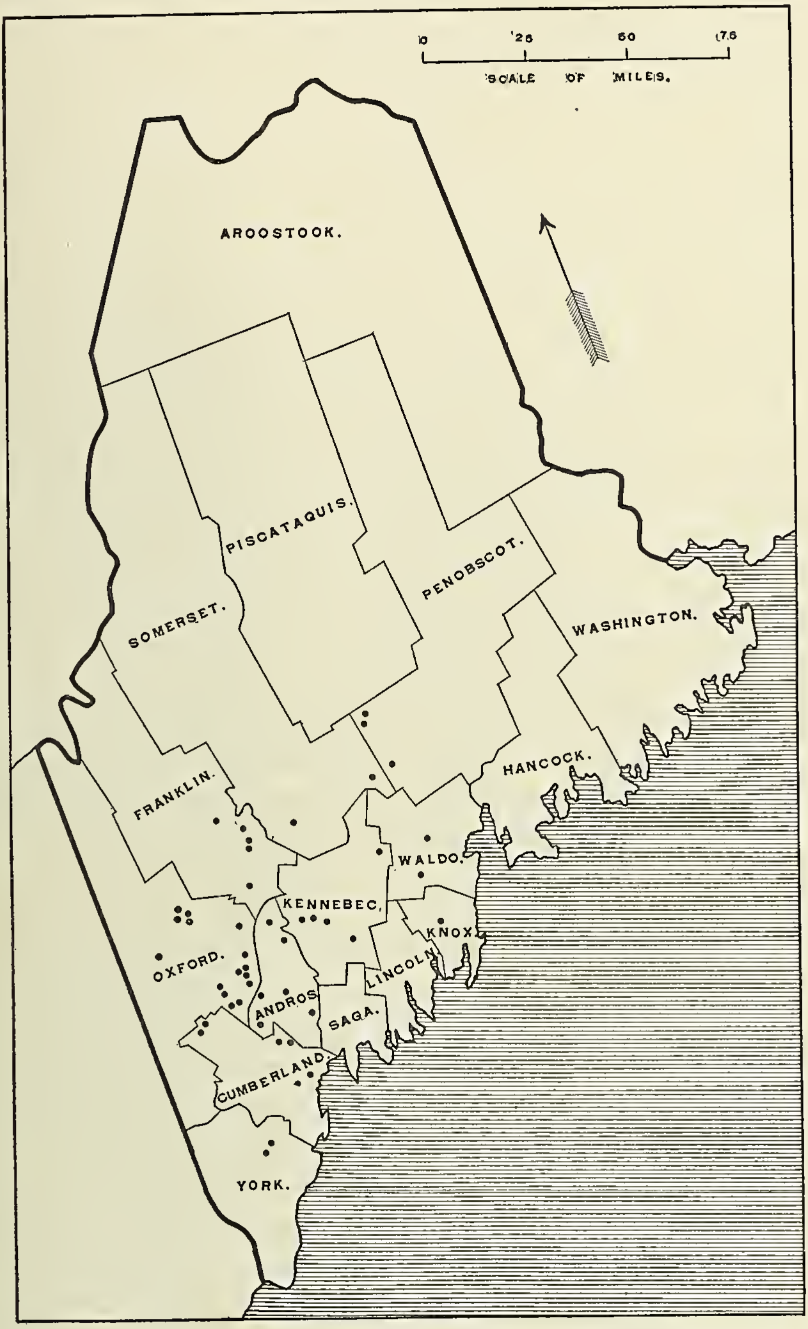

Fig. 231. Outline map of Maine with scale of miles showing by black dots the approximate location of each plot of corn grown in the 1909 farm distribution test.

The plan by which the seed was distributed to the growers was as follows: When the 1908 ear-to-row test plots were harvested the corn from each row was kept separate and sorted into A1 seed, good seed and nubbins (cf. p. 266). Taking all factors into account the 44 rows regarded as the best by us were selected for the farm distribution test. Then after rejecting the corn shelled from nubbins and ears too poor to go in as seed, the A1 seed and good seed from each of these 44 rows was put together in a bag. Each bag then contained the seed from one row of the 1908 ear-to-row tests, and the row in turn was grown from one single original mother ear of the 1907 crop. One such bag of seed was given to each farmer for planting, with strict instructions to avoid mixing this corn with any other. In other words, the farm distribution test was conducted in such a way as to make it the continuation of an ear-to-row test, on a larger scale. No special instructions were given as to planting, each farmer being told to plant, fertilize and cultivate the crop exactly as he would if he had ordinary factory seed.

Elaborate records were taken regarding each of these farm plots and the corn which grew on it. All but one of the plots were visited personally by one or both of the writers at least once, and in most cases twice, during the summer. It is neither possible nor desirable to present here all of the detailed data collected regarding these plots. All that can be attempted here is to give a summary statement of what appears to the writers to be the significant results of this experiment.

In such a statement the following points are to be noted:

1. The season of 1909 was, as has already been pointed out, a very unfavorable one for sweet corn growing, all over the State. The conditions, in other words, were such that the seed put out in this farm distribution test could not show its highest capabilities. This was quite generally recognized by the growers who planted it. A great many of the reports noted that the season was so poor that it was not felt that the seed had a "fair chance." Since, however, the purpose of the test was to compare the selected seed with the ordinary factory seed under the same conditions it is perhaps just as "fair" to make the test under generally unfavorable as under favorable conditions. The only difficulty was that some growers may

have been discouraged from giving the seed further trial in consequence of bad results not entirely, at least, the fault of the seed itself.

2. As was to be anticipated there was a wide variation in the outcome of the tests. In a few cases the plot from the selected seed was practically a total failure, not producing ears worth hauling to factory. In every such case of complete failure the fault was not with the seed, but with various other factors. The corn came up well, but was injured during the growing season. In one case the corn was nearly all killed by the drought and an exceptionally early frost accounted for the remainder. In two cases the corn was planted on such extremely poor soil, not properly fertilized or cultivated, that it could not make a satisfactory growth. At the other extreme were cases in which the corn was highly satisfactory in respect to all characters including earliness, yield and canning quality. Between these two extremes were all gradations.

3. There was practically entire uniformity in all reports that the seed of Type I which was distributed produced a corn of fine quality for canning purposes. That is to say, this selected seed produced ears of clear white color, good shape and size, and with small, deep and well packed kernels in nearly all the different environments in which it produced any crop at all. The uniformity of the reports in regard to this point is in striking contrast to the reports respecting the relative earliness of the corn.

4. In regard to relative earliness, there were great differences in different localities. In some cases the selected seed gave plots two weeks later than factory seed in the same locality. In other cases the selected seed was nearly, if not quite, as far ahead of factory seed. As has already been mentioned, Mr. Heath's plot at Farmington was very early. In a final report on his corn Mr. Briggs at Canton says regarding the earliness of his plot: "We judged it to be about one week earlier than the other (i. e. factory) seed." Mr. Doughty at West Poland found the selected seed earlier than the factory seed. In most cases the reports from the growers and our own observations show that the corn from selected seed was about the same as the factory seed in respect to earliness. The essential point appears to us to be that there is a great deal of variation in regard to the

relative degree of earliness of the corn when seed substantially uniform in respect to this quality is planted in different environments.

5. These results point clearly to the great importance in the production of sweet corn seed of the factor which has been called by Cook * "local adjustment." This investigator found that (*loc. cit.* p. 65): "The growing of a variety of cotton in a new locality is likely to bring about a distinct reduction in the yield as well as in the quality of the fiber. The deterioration has been found to be connected with an increase of diversity among the individual plants. Even when a carefully selected, uniform stock is used for the experiment a much greater amount of diversity may appear in a new place than when the same stock is grown under accustomed conditions of the previous locality where the variety was improved by selection." The results of the farm distribution test appear to us to indicate most strongly that essentially the same conditions obtain in sweet corn as in cotton as described by Cook. This is particularly true in regard to earliness and yield, less so in regard to the quality of the corn for canning purposes.

The importance of this factor of local adjustment in sweet corn may be shown by the citation of specific evidence in addition to the general facts already brought out. In the first place may be considered the cases where it was possible to compare the selected Type I corn in a new locality (environment) with another strain of seed well adjusted to that locality. In every such case which came to our notice in connection with the farm distribution test it was plainly the case that our selected seed did not do so well as the locally adjusted seed, even though the latter might be of a strain or variety really inferior to our Type I, when both were under such conditions as to give the best results. Thus, as mentioned before (cf. p. 280) Messrs. J. H. and F. D. Martin of Rumford Point have a strain of sweet corn which they have grown for seed for 20 years continuously. It is a good though somewhat coarse grained sweet corn but very well adjusted to local conditions. This is evidenced by its earliness, uniformity and yielding quality. A small plot of our Type I seed was planted by these gentlemen in 1909. It was almost a

* Cook, O. F. Local Adjustment of Cotton Varieties. U. S. Dept. Agr. Bur. Plant Ind. Bulletin 159, pp. 1-75, 1909.

complete failure. It was very uneven and irregular in its growth throughout the season. It showed the "diversity" which Cook emphasizes in the case of cotton in a new locality. It was much later than the Martin seed. This contrast between the locally adjusted and the newly imported seed was noted not only in the case of the corn on the Martin farm, but also in the case of two other plots in the same region (about Rumford).

The converse case to that just cited is illustrated by the condition at Farmington. There our Type I seed is locally well adjusted seed, whereas the factory seed is the imported. The superiority in all points of corn from our seed as grown at Farmington over corn from factory seed was beyond question, and admitted by all familiar with the corn in that region.

Another opportunity to observe the effect of this factor was given by the experiments with the Type II corn. The field selections of this corn in 1907 were made in Newport and Dexter. In 1908 the selected seed was planted at Farmington. The experimental plot of this corn was (a) much inferior to the Type I plot; (b) it was much more uneven and irregular in respect to all characters (i. e., showed greater "diversity" in the sense of Cook) than did the locally adjusted Type I on the one hand, or than the equally but differently locally adjusted Type II at Newport and Dexter on the other hand. These facts are readily interpreted on the local adjustment idea. One further point is of interest here. In the 1909 farm distribution test, plots of both Type I and Type II seed were planted at or near Newport and Dexter. While all did very well, the Type II seed clearly gave better results here than the Type I. Further the Type II seed gave much better results than it did the year before at Farmington. The suggestion at once comes to one's mind that these results are possibly due to the circumstance that the Type II seed in 1909 was brought back again in these cases to the locality to which it was "by nature" adjusted, whereas the Type I seed was here in a "new place." Such an interpretation, if true, would clear up at once the apparent paradox of a distinctly superior strain (as our Type I unquestionably is in general as compared with Type II) giving worse results than an inferior strain under the *same* environmental conditions.

The point made by Cook that increased "diversity" very frequently follows the introduction of seed into a new locality finds

distinct and abundant confirmation in the results of the farm distribution test with corn. Specific instances of this have already been cited and need not be repeated. This fact is of great biological interest. The uniformity of well-adjusted corn, and the diversity of ill-adjusted, the "germ plasm," or hereditary constitution being alike in both cases, are equally remarkable.

It might be thought that one point which has been brought out in this discussion of the farm distribution test is opposed to the idea of local adjustment as a factor in breeding of seed corn. This point is that (cf. p. 289) in many cases the selected seed (Type I or II) when put into new localities gave as good or slightly better results than the factory seed. It might at first thought be supposed that the newly introduced seed ought always to give worse results than the other, if the local adjustment idea has weight. Such a conclusion, however, would not, in the writers' opinion, be justified. On the contrary it would appear that such cases as those mentioned merely mean that in those localities the farmers never have experienced and consequently do not know the valuable results which accrue from having seed from a locally well adjusted strain. In such cases the factory seed, as well as our seed, was, and is regularly brought in from some other locality. It is, in other words, just as "new" and on the whole possibly not so good as our selected seed. It is not then surprising that our seed did as well or better.

In general it may be said by way of summary that in the writers' opinion the farm distribution test justified itself many times over by showing so clearly the importance of the adjustment of the strains to local conditions as a factor in the production of seed sweet corn. When this point is realized by the packer and the farmer and intelligent account is taken of it in the growing of seed it will, we believe, lead to entirely different methods than those now followed. It is clear that it will be advantageous to practice such methods of production and selection as will tend to favor and increase local adjustment.

III. Plot Tests.

There were conducted at Farmington in 1909 some experiments to test certain particular points which had attracted attention in the course of the breeding work, and in regard to which it was necessary to have further evidence in order to interpret

the results of the breeding experiments. These tests were carried out on 1-6 acre plots on the intervale land of Mr. Heath's farm, adjoining the ear-to-row plot. Three experiments of this kind were tried, occupying altogether ½ acre of land. These experiments were as follows:

A. *The influence of the number of stalks to the hill upon the yield, quality and earliness of the corn.* In the course of our study of the sweet corn growing industry of the State we have found a very general tendency towards thick planting. The vast majority of farmers make it a regular practice to leave from 4 to 7 or even 8 stalks standing in the hill. The reason for this lies in the desire for stover for feeding purposes. Most farmers who grow sweet corn are also dairymen on a larger or smaller scale. They wish to get as much fodder from the sweet corn as possible. Consequently they plan to have a relatively large number of stalks to the hill. One hears very frequently the argument that since the shortness of the season is liable to cause a complete failure of the crop so far as ears are concerned it is wise to take measures to insure as much fodder as possible, so that some return may be had for the outlay of money and labor. Now a very slight acquaintance with corn teaches one that beyond a certain limit every increase in the number of stalks per hill means a decrease in the yield of ears. It, therefore, becomes a problem to determine where this limit is. Ears of sweet corn mean actual money to the grower. If he deliberately plants in such a way as to sacrifice in some degree yield of ears for yield of fodder it is desirable to know just what that fodder so gained is really costing him. Many farmers seem to proceed on the absurd assumption that in corn fodder they are getting something for nothing. As a matter of fact they often grow sweet corn fodder in such a way that it is probably the most expensive food they give their cattle.

Further, in 1908 the corn in our experimental plots was thinned to one stalk every 18 inches. This corn was earlier than anything we had seen in the State. The point at once arose as to whether part of this earliness might not be due to the amount of space allowed each plant, thus permitting it to make more rapid growth and hasten its maturity.

In order to gain some data regarding these points, a plot of land 144 feet by 50 feet was planted in the following way: the

rows were run the short way of the piece; in each row there were about 33 hills each 18 inches apart as in all our planting, the rows being 3 feet apart; beginning at one side of the piece the first 8 rows were planted with 2 kernels to the hill, the next 8 rows with 3 kernels to the hill, the next 8 rows with 4 kernels to the hill, the next 8 rows with 5 kernels to the hill, the next 8 rows with 6, and the last 8 rows with 7 kernels to the hill. The whole piece was evenly manured and fertilized, there being 150 lbs. of fertilizer put on the 1-6 acre. All the corn was cultivated in the same manner, and none of it was thinned. Every stalk that came was allowed to stand. The seed used was all from the same row (row No. 111) of the 1908 ear-to-row test. That is it all came from one original grandmother ear (ear No. 157). In other words all the conditions except the number of stalks to the hill were so far as possible made the same.

B. *The effect of heavy fertilizing on earliness of maturity.* The most successful sweet corn growers use relatively large amounts of commercial fertilizer in addition to heavy manuring. Where this is done it raises the question as to whether in many cases at least, the observed earliness of maturity which many of these more successful growers get is not primarily an environmental effect due to the abundance of plant food. It is conceivable that an abundance of fertilizer may accelerate the rate of growth, thus getting the corn to maturity earlier. To get some reliable data on this point the following experiment was tried. A piece of land 144 feet by 50 feet (= approximately 1-6 acre) was divided into two equal plots VIA and VIB. The soil was uniform over the whole plot. It was all given a heavy and even coat of manure. The rows were planted the short way of the piece, 3 feet apart and the hills 18 inches apart. The rate of planting was the same all over the piece, 4 kernels being planted to the hill, and the corn thinned to allow 3 stalks to stand in each hill. The same seed was used on both VI A and VI B. It all came from the same row of the 1908 ear-to-row test (row No. 153) and from the same grandmother ear (ear No. 6[illegible]). The only difference between the plots was that when they were planted (May 20, 1909) 75 lbs. of fertilizer were put on VI A (being put in the hills, in the usual way), whereas no fertilizer whatever was put on VI B.

C. *An experiment regarding selection for earliness of maturity.* In the 1908 ear-to-row test the row which was by far the earliest in the plot was No. 131, and the row which was latest in maturing was No. 133. The differences between the two in this regard are indicated by the following notes:

Character.	Row 131	Row 133.
Tassels well out	July 9	July 15
Silks well out	July 20	July 27
Silks dry	August 3	August 12
First ears ready to harvest for mature seed	August 20	September 4
Ready for general harvest of mature seed ears	August 24	September 12

The seed from both rows was *fully matured* when harvested. This is an important point to be kept in mind in relation to the discussion of the results below.

In 1909 a piece of land 144 feet by 50 feet (= about 1-6 acre) was divided into two equal plots IV A and IV B. Both were treated in exactly the same way in preparation for planting and given an even coat of manure and the same amount of fertilizer (75 lbs. on *each* plot). The rows were as usual 3 feet apart and the hills 18 inches. The soil was of the same character over the whole piece. The corn was planted May 20, 1909, 4 kernels to the hill, and the corn was thinned to leave 3 stalks to the hill. Plot IV A was planted with a *random sample* of the seed harvested from the early row No. 131, and plot IV B with a *random sample* of the seed harvested from the late row No. 133. It is important to remember that the seed for IV A was *not* a *selection* from the earliest plants of row 131, and that for IV B was *not* a *selection* of the latest from row 133. In both cases the seed was a random sample.

Results From Experiment A.

The corn in this experiment germinated well, and an even stand was obtained in each of the sub-plots. Of course every kernel planted did not come, but the average lag in number of *stalks* per hill behind number of *kernels* per hill was substantially the same over the whole piece. As the corn grew the plot as a whole presented a striking appearance. On the side where there were 7 kernels to the hill the growth of leaves was rank and luxurious. At the other extreme the corn had a very thin appearance, though what there was of it was thrifty enough.

The results of this experiment are shown in Table 10. In this table "green" refers to the condition of the corn when harvested for seed. Sweet corn thoroughly matured in the field contains between 50 and 60 per cent. of moisture as compared with its air dry condition.

TABLE 10.

Results of Experiment on Effect of Number of Stalks per Hill on the Yield.

	Good Seed Ears			Nubbins		
Kernels per hill.	Weight of green ears in pounds.	Calculated weight of dry ears in pounds *	Bushels per acre.**	Weight green in pounds.	Weight dry in pounds. *	Per cent of total weight of corn borne upon nubbins.
2	130.00	54.00	31.86	7.50	3.12	5.46
3	155.50	64.60	38.12	11.75	4.88	7.02
4	167.50	69.58	41.06	15.75	6.54	8.59
5	119.25	49.54	29.24	16.75	6.96	12.30
6	117.75	48.91	28.86	26.50	11.01	18.37
7	85.00	35.31	20.84	29.00	12.05	25.57

* Calculated from a shrinkage factor determined for this corn by weighing a definite amount of corn when harvested and again when thoroughly air dried. The value of this shrinkage factor for this sweet corn is 58.5 per cent. That is 100 lbs. of corn when harvested, will weigh 41.5 lbs. when air dry.

** Calculated in this and the following tables on the basis of 61 lbs. of air dried ears to the bushel.

The most important of the facts brought out by this table are shown graphically in Figs. 232 and 233.

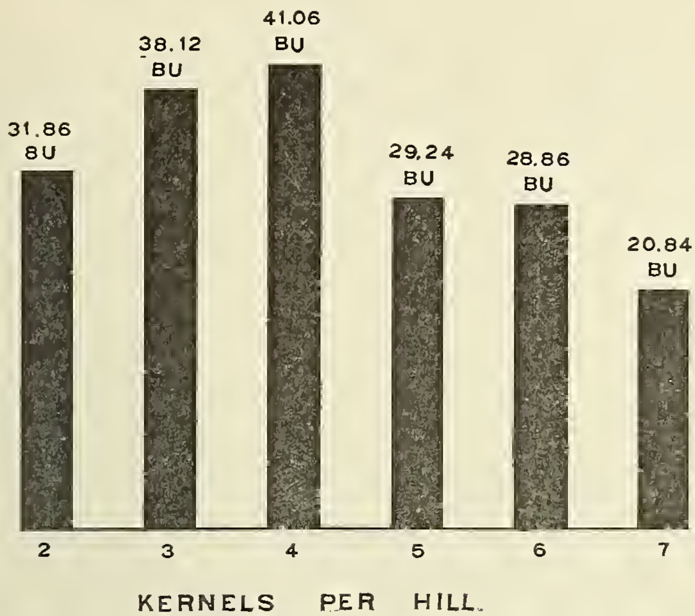

Fig. 232. Diagram showing the relative rate of yield in bushels per acre of sweet corn according to the number of kernels planted to the hill, without subsequent thinning.

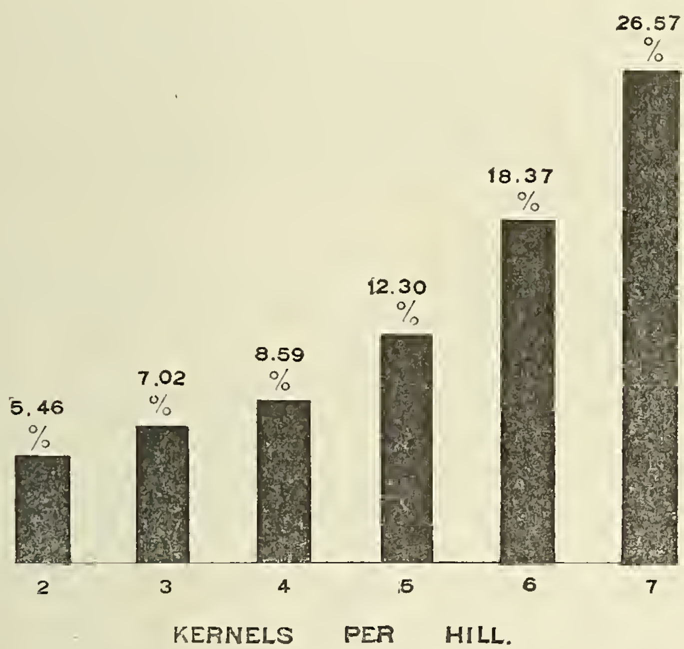

Fig. 233. Diagram showing the percentage weight of corn on nubbins in the total yield, according to the number of kernels planted to the hill, without subsequent thinning.

From this table and the diagrams we note the following points:

1. The highest yield of corn was obtained from the rows where 4 kernels were planted to the hill. Or, in other words, the largest amount of ear corn is obtained with an average stand of between 3 and 4 stalks to the hill. It is of interest to note that this is in agreement with certain results of this same kind of an experiment with field corn recently reported by Williams and Welton (*loc. cit.*).

2. With 3 kernels to the hill the rate of yield per acre is within 3 bushels of that with 4 kernels to the hill, and is nearly 10 bushels *higher* than with 5 kernels to the hill. Now 5 kernels to the hill in our plot meant an average stand of only a little over 4 stalks to the hill; and 3 kernels to the hill an average stand of about 2½ stalks to the hill. The present figures do not support the contention so frequently made in Maine that 4-5 *stalks* to the hill represent the ideal condition.

3. The rate of yield of ear corn in this experiment was actually higher when only 2 kernels were planted to the hill than when 5 or any higher number were planted. It must be remembered further that this was with seed of high germinating capacity and on the very best of corn land. If any land in the State can stand a high number of stalks to the hill it is that on which this experiment was carried out.

4. In this experiment there was practically no difference in yield between the rows planted with 5 and those with 6 kernels to the hill.

5. The rows planted with 7 kernels to the hill yielding at the rate of approximately 11 bushels to the acre less than those planted with 2 kernels to the hill.

6. The proportion of the total yield borne upon nubbins unfit for use for any purpose but feeding increases as the number of stalks to the hill increases. In the rows planted with 7 kernels to the hill more than 1-3 of the total yield was on nubbins. This matter of the quality of the ears produced is a very important one practically, especially if one is raising seed corn.

The general result of this experiment is quite clear and bears out the impression which the writers have gained from three years general study of the sweet corn growing industry in the

State. It is that even on the best of sweet corn land, heavily manured and fertilized, one can have a final average stand of more than 3 to 3½ stalks to the hill only at a heavy sacrifice in respect to yield of ear corn, when the hills are as close together as in this experiment. Of course it is impossible to make any general recommendation as to what is the best stand to have in any particular case. It depends on the character of the soil, the closeness of the hills together, the amount of fertilizer and manure used and still other factors. The important consideration is that he deludes himself who supposes that by planting 6 to 8 kernels to the hill, and thinning to 5 or 6 stalks (as many do) he is getting something for nothing in the fodder. He pays dearly for that fodder in the reduced yield and poor quality of his ear corn. We have yet to see any place in Maine where, under the usual conditions of planting and cultivation, the best results with sweet corn are to be obtained with an average stand of 4 or more stalks to the hill. There can be do doubt that many dollars are deliberately thrown away every year by the farmers of Maine by planting their sweet corn too thick. The farmer who wants fodder corn for his silo will do vastly better to plant a good strain of ensilage corn, than to try to get a good money return at the corn factory and fill his silo at the same time and off the same land. No American dairy farmer would think of using his cows both as milk producers and draft animals at the same time, yet many of them are trying to do what is essentially the very same kind of a thing with their sweet corn.

One of the chief objects of this experiment was to test the effect of the number of stalks per hill upon the earliness of the corn. As stated above (cf. p. 293) it was thought possible that the reason we obtained such marked improvement in earliness in 1908 was because each plant was allowed more space than is customary. The results of the present experiment make that conclusion unlikely. Notes regarding the earliness and other characters of these plots were taken every few weeks during the entire growing season. At no time was there any marked difference in the earliness of any of these plots. The plot with 7 kernels per hill and the one with 2 kernels per hill were ready for harvesting at practically the same time.

RESULTS OF EXPERIMENT B.

In this experiment, as was to be expected, the two plots VI A and VI B showed very marked differences throughout the season. The corn germinated well and evenly. A full stand was obtained on both plots. The corn in plot VI A grew faster and made more even and ranker growth than that in VI B. On June 19, 1909, the corn in the fertilized plot was about one-third larger than that in the plot without fertilizer. On July 12, the corn on the fertilized plot showed much ranker growth than that on the unfertilized plot. There was, however, very little difference in respect to earliness. About the same number of plants showed tassels in the one plot as in the other. During the latter part of the season the corn in the unfertilized plot grew better relatively than it did during the first half of the season. This was undoubtedly due to the manure which the plants were able to use about this time. When the corn was ready for harvest the plants in the unfertilized plot were about one foot shorter on the average than the rest of the field. There was practically no difference in the time of maturity. Both plots were ready for the factory and for seed at the same time. From this experiment it would seem that the amount of fertilizer has very little effect upon the time of maturity of this corn at least when grown under conditions to which it is locally well adjusted.

With regard to the yield, however, the case is different. Table II gives a summary of these two plots with respect to yield.

TABLE II.

Results of Experiment on the Effect of Commercial Fertilizer on the Yield.

Plot No.	Good seed ears.			Nubbins.		Percent. of total weight of corn borne upon nubbins.
	Weight of green ears in pounds.	Calculated weight of dry ears in pounds.	Bushels per acre.	Weight of green corn in pounds.	Calculated weight of dry in pounds.	
VI A (Fertilizer)	565.75	235.01	46.23	98.00	40.71	14.25
VI B (No Fertilizer)	308.50	128.15	25.21	121.00	50.26	28.17
Difference	+257.25	+106.86	+21.02	—23.00	—8.55	—13.92

The following points may be briefly noted:

1. When commercial fertilizer was applied at the rate of 900 pounds per acre in addition to a good coating of manure the yield was increased 21 bushels per acre over the yield of the plot to which manure alone was applied. At the current price of $4.00 per bushel for sweet corn seed the return from the application of less than one-half ton of fertilizer would have been about $84.00.

2. When no fertilizer was used, corn grown on nubbins too poor for seed was about 14 per cent. more than in the fertilized plot. Further the quality of the seed ears from the unfertilized plot was inferior to that of the ears from the fertilized plot.

Results of Experiment C.

The corn in each of these plots germinated well and gave an excellent, even stand. The following brief extract from our notes on these plots will make clear their general course of development. On June 19, 1909, there was a good even stand with no hills missing. There was no observable difference between the plots in any respect. On July 12, 1909, there was no apparent difference as to earliness. Many plants in both plots were in tassel. There was, however, a difference in the general appearance of the corn. Plot IV A had a lighter color, narrower leaves and the growth was not so rank as in IV B. On August 28, 1909, plot IV B still showed a ranker growth and the ears appeared longer than those in plot IV A. The latter plot averaged to have more ears to the hill and the ears were of good shape, but rather short. In these particulars the plots resembled their parent rows (No. 131 and No. 133) of the previous season. At this time there was a *very slight* difference in earliness in favor of plot IV A. This difference was very small. It was not nearly so striking as it had been the year before between rows 131 and 133. This may be accounted for partly by the intermingling of the pollen from these two rows in 1908. But it does not seem probable that this had very much to do with it because the two plots showed such characteristic differences in other respects as in the manner of growth, width of leaves, etc. It is a very interesting fact that the selection of a random sample of seed from the earliest and

latest rows of the 1908 plot should produce only such a slight effect on the earliness in the next year's crop.

Many of our results seem to indicate that earliness, in a large part at least, is a physiological rather than an hereditary phenomenon. There seems to be no doubt but that corn once adapted to its local environment can be improved in regard to earliness by a rigid selection of the earliest plants for one or two years. After that it seems doubtful if any farther improvement can be made by selection for earliness, unless the corn becomes better adapted to local conditions. This matter will be tested farther and discussed more fully in a later publication.

Table 12 gives a summary of these two plots with respect to yield. It is very remarkable that these two plots should yield exactly the same amount of seed corn. Plot IV B had a slightly larger per cent. of its corn on nubbins but the difference is insignificant.

TABLE 12.

Yield of Plots Planted with Seed from an Early and a Late Row.

Plot No.	Good Seed Ears.			Nubbins.		
	Weight of green ears in pounds.	Calculated weight of dry ears in pounds.	Bushels per acre.	Weight green in pounds.	Calculated weight dry in pounds.	Percent. of total weight of corn borne on nubbins.
IV A (Early)....	386.50	160.55	31.58	75.50	31.36	16.34
IV B. (Late)	386.50	160.55	31.58	87.00	36.14	18.37

SUMMARY AND DISCUSSION OF RESULTS.

This report deals with a portion of the results of experiments in breeding sweet corn extending over a period of three years. The more important of these results and the conclusions drawn from them may be summarily stated as follows:

1. Two types of corn were dealt with in the experiments. The history and characteristics of each of these are given. They are both white in color, and differ chiefly in regard to earliness of maturity and fineness and depth of kernel. The corn which is here designated as Type I is the superior variety in regard to these characters. It approaches closer to the ideal type of the corn packer than any corn grown in the State.

2. Both of these types have been subjected to selection in these experiments. The primary objects of the selection were to improve the corn in respect to (a) earliness of maturity, (b) yield, both of ears and stover, and (c) the general conformation of the ear, especially with reference to shape and to the covering of the tip with kernels. Earliness was regarded as the most important point.

3. The selection practiced was twofold. In the first place desirable *plants* were selected in the field and then the ears harvested from these plants were subjected to a further selection for size, conformation, etc.

4. A marked gain in earliness was observed after the first year's selection of the Type I corn. This gain was maintained in the subsequent year in the same locality where the corn had been grown in previous years. There is no evidence that there was any further gain in earliness following a second year's selection. This conclusion is still further borne out by the experience of 1910 involving a third year's selection. A three acre plot of Type I corn from seed selected for earliness is growing this year at Farmington and is, by a considerable amount, earlier than any other sweet corn in the region. Yet, making due allowance for differences in the seasons, it does not appear to be relatively earlier than was the selected corn in the ear-to-row tests in 1909 and 1908. In other words all the gain which has been made in earliness was accomplished in the first year's selection. No further increase has followed the further selection practised in the two subsequent years.

5. The Type II corn selected in 1907 was grown in a new locality (for it) in 1908. Under these circumstances no general gain in earliness was found, though there were individual rows which were distinctly early for that type of corn. The "new-place" effect appeared quite to outweigh the effect of selection so far as the general Type II crop in 1908 was concerned.

6. There was in general a marked improvement in respect to conformation of ear (including shape, fineness of kernel and quality of tip and butt) following the first year's selection. This gain has been maintained where the corn has been grown in localities to which it is well adjusted. A study of the sweet corn in the field in 1910 confirms this conclusion by another year's work.

7. Two years' ear-to-row tests furnish no evidence that there is any close association or correlation between the size or conformation of the seed ear and the *yield* of corn obtained from it upon planting. The large, well tipped. and beautifully shaped ear is as likely as not to prove a poor yielder when planted. This result means that the external. visible characters of the ear are a very unreliable indication of its probable worth for seed purposes. This is the same result to which all recent experimental studies of breeding appear to lead.

8. The present experiments point clearly to the conclusion that in any attempt to improve corn by selection the fundamental datum must be the performance of the *row* planted on the ear-to-row system (i. e , the performance of the *progeny* of an ear) rather than the individual ear or plant. In other words, the selection of the best *individual* cannot alone be depended upon for improvement. A poor genotype may often yield a good individual. The function of selection must be to discover and separate the desirable genotypes from the poor ones.

In making this statement it is not intended to advocate the isolation (whether by extreme pedigree selection or by hand pollination) of a *single* pure line or homozygote strain as the thing to be aimed at in practical corn breeding. Shull and East (cf. *infra*), who have isolated *pure* lines of maize, have both found that such corn yields very poorly and is altogether undesirable from the practical standpoint, lacking particularly in vigor. Apparently vigor and yielding quality in maize depend

to a large degree upon the maintenance of "broad breeding," i. e., of a heterozygous condition in the strain. From the practical standpoint it seems to us that the aim of corn breeding should be to get rid of poor genotypes and leave the good. There will under all ordinary conditions be enough of these latter to insure the heterozygote condition in the strain, particularly if, on the one hand, the all selected corn is planted on the ear-to-row system in a single plot and no detasseling is practiced, and, on the other hand, a deliberate attempt is not made in the selection to reduce to the lowest number possible the female lines involved in the pedigrees, as by taking the seed ears for a subsequent year's ear-to-row plot *all* from the *same* row of a plot planted on the same system, and keeping up this practice through several years. We are very much inclined to believe that in actual practice substantially as good results may be obtained by a general ear-to-row selection method, relaxed in intensity after a few years, as by the use of the more elaborate and costly "pure line method of corn breeding" of Shull. The latter method is probably right in principle, but the former method, in a much cruder and less precise way, really makes use of the same principle. Continued ear-to-row breeding (without too close pedigree selection) is continually testing out different heterozygote types and rejecting the undesirable ones. Presently a point will be reached where the great majority, if not all of the more strikingly undesirable genotypes (which when crossed produce the undesirable heterozygotes) will have been automatically eliminated. We shall then have reached by a much slower route the same goal which Shull attains quickly and directly by his "pure-line" method.

The rejection of undesirable genotypes can be most readily accomplished practically through the ear-to-row system of planting. Naturally one will never expect to get such rapid results following selection with an open fertilized plant like corn as with a self fertilized plant like the bean. One can not so quickly get rid of the influence of all poor genotypes.

9. Without wishing in any way to be dogmatic in the matter it appears to the writers that the results obtained in these selection experiments with corn indicate that inheritance in this form is fundamentally in accord with the "pure line" or genotype

idea of Johannsen with, of course, the limitations implied by the fact that it is an open fertilized plant. In so far these general results agree with the analytical studies of Shull and of East* having particularly to do with this point. We find the results of this experimental investigation to be very difficult (if not altogether incapable) of rational interpretation in accordance with the biological implications of the "law of ancestral inheritance."

10. The experiments, so far as they go, give no evidence that there is a cumulative effect of the selection of small fluctuating variations in sweet corn, though, of course, it is recognized that too short a period of time is covered to give any definite evidence on this point. It is believed (as already indicated in 8 and 9) that the observed favorable results which have followed selection in this work are to be explained as the result of the separation of a number of already existing genotypic lines possessing desirable qualities from the still more heterogeneous strains with which the work was begun. This is obviously, however, *in the present case* merely a matter of interpretation. It does not in any way influence the practical conclusion to be drawn from the empirical results, namely that if improvement does follow (as is the case) it is wise to practice selection.

11. A wide distribution of selected sweet corn seed over the State in 1908 demonstrated the importance of the factor of local adjustment (Cook) in the improvement of this crop by breeding. The good effect of selection may be quite obliterated as a result of planting the seed in a new locality. The emphasis which such results place upon the importance of (a) selecting for local adjustment, and (b) growing the seed in the locality in which it is to be used is obvious. During the summer of 1910, while this bulletin was passing through the press, a field trip was made by the writers covering a considerable part of the corn growing region of the State. The observations made in the present year confirm completely those made in connection with

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* Shull, G. H.—The Composition of a Field of Maize. Rept. American Breeders Assoc. Vol. IV., pp. 296-301, 1908. See also a further paper by the same author having the title "A Pure Line Method in Corn Breeding: *Loc. cit.* Vol. V., pp. 51-59. 1909.

East, E. M. The Distinction between Development and Heredity in Inbreeding. Amer. Nat., Vol. XLIII., No. 507, pp. 173-181. 1909.

the farm distribution test last year, in respect to this matter of local adjustment. In several localities where last year the Type I corn from the Station was nearly a complete failure, and much inferior to the facory seed, it is this year doing very well. The apparent loss of earliness and fine quality (due to "new place effect") is clearly seen not to have been a real loss at all, but merely an expression of lack of local adjustment. Thus it results that while in 1908 it was not possible to find anywhere in the State corn as early as the Type I at Farmington, such is not the case in 1910. Other plots of the Station Type I corn in other parts of the State where selection of a kind which amounted to selection for local adjustment was practiced last year, are this year nearly or quite as early as that at Farmington. Altogether our results clearly indicate that the local adjustment factor cannot be neglected in corn breeding work, whether one is concerned with practical results or scientific analysis.

12. Experimental plots designed to test the effect of commercial fertilizer, in addition to manure, upon yield and earliness showed an increased yield of 21 bushels of dry seed per acre in favor of the fertilized plot. On the fertilized plot there was less corn on nubbins and the remaining ears were of better quality. There was no effect on the earliness of maturity. Both plots were ready for harvest at the same time.

13. Random samples of seed from the earliest and from the latest rows in 1908 were planted in 1-6 acre plots in 1909. Both plots matured very early and at practically the same time. There was a very slight difference in favor of the seed from the earliest row. This difference was nothing approaching in amount what it might reasonably be expected to be if the pimary factor concerned in earliness of maturity in this plant were definitely inherited.

14. No attempt is made at present to discuss the biological basis of the improvement in earliness observed to follow selection for that character in these experiments. We are inclined to the belief that much, if not all, of this improvement is in reality a physiological rather than a genetic or hereditary phenomenon. The whole subject of breeding for earliness is one which needs more critical discussion and experimentation than has hitherto been given it.

On the basis of the experiments and observations reported in this bulletin, some practical suggestions regarding the growing of sweet corn in Maine have been prepared. In these suggestions there is outlined a simple plan of corn breeding which can readily be put into operation by any farmer or packer in the State.

The observations made by the writers during the four summers in which they have been in the field studying the sweet corn industry in the State have led to the conviction that there is both a great need and a great opportunity for seed improvement with this crop. The best interests of the farmer and the packer are in no conflict over this matter. The two great practical lessons which have grown clearer and more certain as the work has progressed are that to get the best results (from both packer's and farmer's standpoint) it is necessary first that definite *seed selection* be practiced to improve *earliness, yield* and *quality* of ear, and second that, notwithstanding a more or less widespread impression to the contrary, *locally grown and bred seed gives the best results,* provided, of course, that it is *well* grown and *well* bred. The best sweet corn in Maine today is grown from *locally* produced seed.

PRACTICAL SUGGESTIONS REGARDING THE GROWING OF SWEET CORN FOR PACKING AND FOR SEED.

The following pages contain some practical points regarding the raising of sweet corn in Maine which have grown out of three years work in (a) the experimental breeding of this crop, and (b) the observation of current farm practice and its results covering practically the whole of the sweet corn producing regions of the State. A complete report of this work, which forms the basis of these suggestions and *which should be read in connection with them,* is given in the foregoing sections of this bulletin. The evidence in support of the suggestions here made is to be found in that portion of the bulletin. It must of course be understood that these suggestions, like any others regarding practical farming, must be applied with common sense and due regard to local conditions as to soil, etc. The suggestions are grouped under three heads as follows: A. Growing Sweet Corn for the Factory. B. Growing Sweet Corn for Seed. C. The Care and Curing of Seed.

A. Growing Sweet Corn for the Factory.

1. *Plant early.* The growing season in Maine is short under the most favorable circumstances. Under present conditions the farmer must take chances at one end of the season or the other. Too often he plants in such a way as to take them at both ends. General observation shows beyond any question that the farmers who are most successful with sweet corn (i. e., who make the most money at the factory year in and year out) are those who plant relatively early. That is, they elect to take their chance at the beginning rather than the end of the growing season. At the worst they may have to plant a part of the piece over again. Whereas if the loss is by frost in the fall it is total and irreparable. Observation indicates that it should be a rule to plant as soon after May 15 as the soil is in condition.

2. *Use plenty of manure and high grade commercial fertilizer.* Too many farmers try to grow sweet corn without any or with too little commercial fertilizer. This is a suicidal policy under Maine conditions. 800 to 1000 pounds of fertilizer to the acre is not too much for most land on which sweet corn is grown in the State.

3. *Keep the corn clean from weeds and well cultivated.* The corn should be cultivated at least once a week until it is too tall to allow the horse to get through without breaking the leaves. It should be hoed by hand at least twice, and preferably three times. All cultivation must be shallow or the roots will be injured.

4. *Do not plant too thick.* Here is where a mistaken policy is most often followed. Experience shows clearly that when sweet corn is planted in rows three feet apart and with the hills 18 inches apart in the row, it is very unprofitable both as concerns the amount and quality of the ears, to allow more than 3, or at the very outside, 4 stalks to stand in the hill. 3 stalks to the hill is better than 4.

5. *Use seed well adjusted to the locality in which it is to be grown.* Extensive experiments and observation shows most clearly that the best results cannot be expected from seed produced in another locality and in a different environment from that in which it is to be planted. It is to the common interest of both the farmers and the packers to use not merely Maine grown but locally grown sweet corn seed. This seed should be selected for local adjustment (see below). The farmer, in his own interest, should avoid new kinds of seed which he has not found to give satisfactory results on his own or his neighbor's farm.

B. Growing Sweet Corn for Seed.

1. *Use home grown seed.* Experiment and observation indicate that it is to the best interest of the packer and the farmer that an arrangement be made whereby in connection with practically every factory enough seed shall be locally produced each year to supply the growers contributing to that factory. This will necessitate that, according to the size of the factory, from 2 to say 6 farmers shall, under the supervision of the packer

concerned, make a business of growing seed corn. The utmost care should be given to the selection of seed, looking towards the improvement of the strain. Suggestions regarding such selection follow. There is little doubt that it would be extremely advantageous from all points of view to have only one variety or strain of sweet corn grown in a locality. The gain in uniformity of product which would follow would be of great value to the packer. If not desired, however, there is no reason why the production of improved, selected seed should be confined to a single variety. The important thing is that, whatever the variety or varieties to be grown, the seed shall be locally produced.

2. *Plan for breeding improved seed sweet corn.* The following detailed plan is drawn up for the guidance of farmers and packers who desire to undertake the production of seed corn. It will, of course, be understood that business reasons make it imperative that the control of the sweet corn seed, if not the actual growing of it, be in the hands of the packers.

A. *First year's work. Field selections.* In the first year's work towards an improved strain of seed only the field selections of plants from which ears are later to be used for planting can be made. These selections should be made of the growing plants in the field. The fields from which seed is to be taken should be gone over at least two and preferably three times in making the selections. The first time may best be about the time the corn is ready for the factory or a little before. In choosing plants to be saved for seed look out for the following points in the order named. In going over the field one should provide himself with some strips of cheap bright colored cloth, about 2 feet long and 2 to 3 inches wide. When a stalk is selected to be saved for seed one of these cloths should be tied around it just below the tassel. This marks the plant so that it will be saved when the rest of the crop is cut.

1. *Earliness.* Whatever other good points a stalk may have do not save it for seed unless it is conspicuously earlier (i. e., more advanced in its growth) than the others around it This is most important.

2. *Size and vigor of plant.* Take only stocky plants with broad leaves, bearing good sized, and so far as can be judged at this stage, well shaped ears.

3. *Adjustment of plant.* Take only stalks which show the characters which are typical for the variety you are working with. Avoid freaks.

The field in which the selections are made must obviously be cut by hand, so that the marked plants may be left standing to mature their ears. As to the number of plants to be selected one must be governed by the extent of the proposed seed breeding operations. The only point to be observed here is to save about twice as many plants in the field as you expect to want ears for planting the breeding plot the next year. This is to allow for the subsequent ear selection in the winter.

When the selected plants are well matured (stalks and husks dead and drying) they should be harvested, and the ears should be husked and cared for in the manner described in the next section.

After the ears from these plants are well dried on the racks (say in December or January) the best of them should be picked out for shelling and planting. In selecting the ears for planting pay attention to the following points.

1. *Fineness of grain and maturity.* Take only ears having small, well packed grains in straight rows, and with the grains set firmly on the cob. Select no ears with fewer than 14 rows (better 16).

2. *Size and shape of ear.* Aim to select ears which are of medium size, nearly cylindrical in shape, and with butt and tip fairly well covered with grain. Do not reject an otherwise good ear because the tip is slightly defective.

3. *Germination.* Test the germination of each ear by taking 25 kernels from the middle of the ear and either placing them between two layers of wet blotting paper in a plate, or by placing them in a small box of wet sand. Keep the germination dishes or boxes in a warm room, and well moistened all the time. Reject all ears from which more than 2 kernels out of the 25 fail to germinate within 10 days. Our experience indicates that the germination of corn largely depends upon the way it is cured after harvesting (see below).

Having selected the ears for planting shell them, keeping the grain from each ear by itself in a paper bag. In shelling reject the kernels at the butt and tip, say for about ¾ inch back from

each end. At this stage, each ear finally selected for planting should be given a number. This number may be written on a slip of paper and put in the bag with the shelled seed.

B. *Second Year's Work. Breeding and Propagation Plots.* The corn should be planted each year in two plots, one the breeding plot and the other the propagation plot. In planting the corn for seed use the best corn land you have, and manure and fertilize it well. Plant the rows 3 feet apart and the hills 18 inches apart in the row. Plant 4 kernels to the hill and thin to leave the *two* best stalks standing in the hill. Give the plots the best cultivation you can.

1. *Breeding plot.* In this should be planted the selected ears. The planting here should be on the ear-to-row system That is, each selected ear should be planted in one row by itself. The row should be given the number borne by the ear which is planted in it. Careful observation should be made of the growth of each row throughout the season. Each row should be harvested separately at the end of the season, its yield determined, and the ears from it kept separate from the ears from all other rows.

The seed from the best *rows,* those showing greatest earliness and highest yield of good quality corn and stover, should be used to plant the propagation plot of the third year. In saving this seed reject all nubbins and poor ears.

The seed from the second best rows (i. e., those not selected for the propagation plot) may be distributed by the packer. This will be good seed, better adjusted than the ordinary factory seed to local conditions, but will not be the best.

2. *Propagation plot.* In the propagation plot of this year plant the good ears from the previous years selection which were *not* used in the breeding plot. They represent plants selected for earliness and local adjustment, and should be only second to the best, which were used in the breeding plot. It is desirable though not absolutely necessary in the propagation plot to detassel every alternate row. Detasseling is done by pulling out and throwing away the tassel (spindle) as soon as it appears, and before the male flowers which it bears have time to open and discharge their pollen. The ears from the detasseled rows are to be regarded as the best seed, and those from the rows where

the tassels were not removed as second best. The two classes should be harvested and cured separately. Seed from the detasseled rows will probably be found to yield better than that from the others.

3. *Individual plant selection.* Just as in the previous year the best individual plants from both the breeding and propagation plots should be marked with cloths and saved separately to furnish seed for the following year's ear-to-row breeding plot. If one desires he may breed a pedigree strain, by keeping the ears from the selected individual plants of a particular row separate by themselves. In this way the plants in such a strain will all be descendants of the same original mother ear.

C. *Third and succeeding year's work.* 1. *Breeding plot.* Plant on the ear-to-row system the individual ears selected in the previous year.

2. *Propagation plot.* Plant with seed from the best *rows* obtained in the *breeding plot* (ear-to-row) of the preceding year. In the propagation plot detassel every alternate row and distribute to the farmers the seed from the *detasseled rows* as *best* seed, and that from the rows not detasseled as second best seed (possibly at a slightly lower price).

3. *Individual plant selections.* Make these each year to furnish seed for the following year's breeding plot.

In suggesting this plan for improving the sweet corn seed used in the State the Station does not, of course, desire to force it on anybody. It must depend upon the foresightedness and progressiveness of the packer and farmer to decide whether it (or some similar plan having the same object in view) shall be adopted. It can only be said that no prediction can be more safely made than that the packer, and the farmers who grow corn for him, who will consistently follow the plan for a period of five years will be abundantly satisfied with the results in terms of dollars and cents at the end of the period. The advice of the Station Staff as to details in regard to breeding corn is, of course, always available to any packer or grower who desires to undertake such work.

C. The Care and Curing of Seed.

General experience indicates that the quality of a corn crop depends to a great extent on the way in which the seed from which it was raised was cured and cared for before planting. The following points are believed to be essential to the best results, and may be of help to the farmers of Maine.

1. *Harvesting.* Corn intended for seed must be fairly well matured, yet must not be chilled or frozen. The stage at which it may safely be harvested for seed is therefore an important point to know. In regard to this it may be said that corn may be harvested for seed as soon as the husks dry. However, the longer it can be *safely* left in the field after this the better it is. So far as germination alone is concerned the care after harvesting is relatively more important than the actual stage at harvesting, provided the kernels have begun to harden and glaze.

2. *Drying or curing.* As soon as possible after harvesting seed corn should be husked and the ears put in a *warm dry room* (temperature not lower than 50 degrees at any time) in which there is some circulation of air. To get the best results they should never be put in a cold shed or barn chamber, as is too often done. Seed corn is probably more often injured soon after harvesting by (a) chilling and (b) becoming alternately moistened and dried, than by any other causes. After drying is begun the corn should not be allowed to become moist, or even to stay in a moist atmosphere until it is planted. To get the best results it will be necessary to use some artificial heat (from a stove or furnace) in drying the corn. Any one engaged in the business of raising seed corn should have a special drying room.

3. *Storage during and after curing.* To get the best results with seed corn it is necessary that during the curing process and until the corn is shelled no ear should be in contact with anything but the surrounding air. In this way the air circulates around each kernel. The corn then does not mould and cures quickly and evenly. This condition can best be realized by the use of storage racks. The rack devised and used by the Station has the form shown in the following illustration. It has been found very satisfactory.

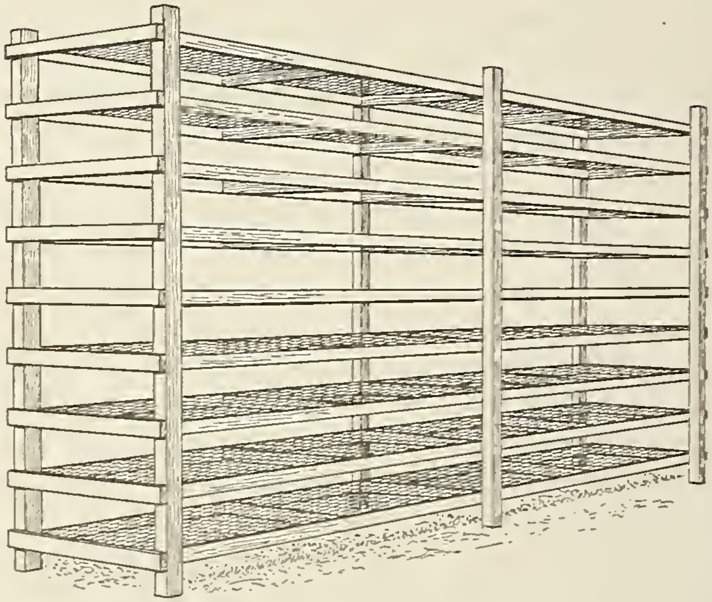

Fig. 234. Photograph of rack for drying seed sweet corn.

This rack is 12 feet long, 6 feet high and 2 feet wide. The uprights are of 2 inch x 3 inch stuff and side pieces 2 inches x 1 inch. The shelves are 8 inches apart. Over each shelf is stretched 2 foot wire poultry fencing of 2 inch mesh. The ears are laid on these shelves in such a way that no two ears touch each other. In this way only a few kernels of each ear rest upon the wires and the air can circulate freely through the whole rack.

The racks used by the Station and here illustrated are built with 9 shelves. They may, of course, be built with more or fewer than this number to suit particular conditions. It is not advisable, however, to make such racks much taller than those here described, because of inconvenience in reaching the corn on the shelves.

These racks may be readily converted into mouse and rat proof closets by covering them on sides, ends, top and bottom with wire fly screening. If this is done the screening on one side should be put on in the form of hinged doors.